

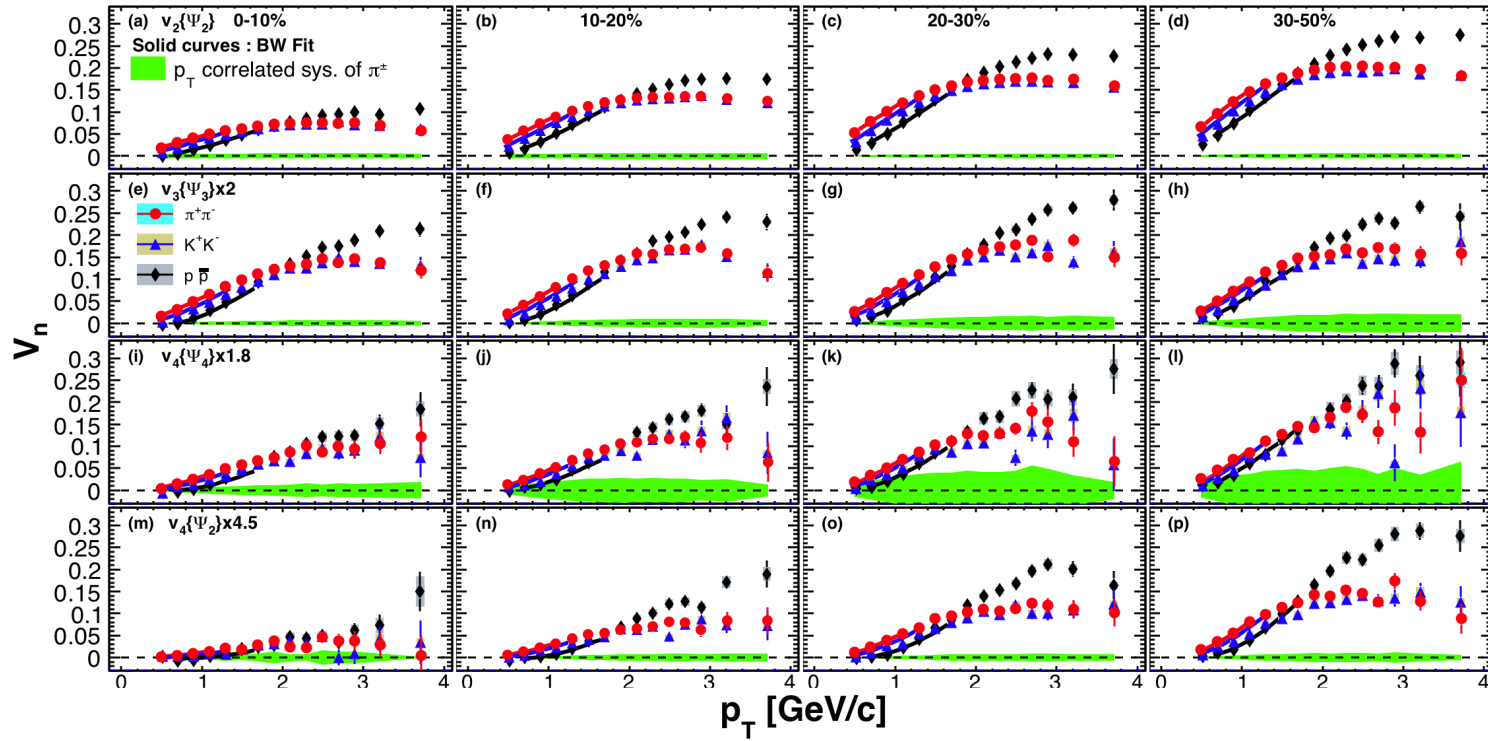
Flow, HBT, and selected recent results from PHENIX

Paul Stankus

Oak Ridge National Lab

RHIC/AGS Annual Users' Meeting, June 12, 2015

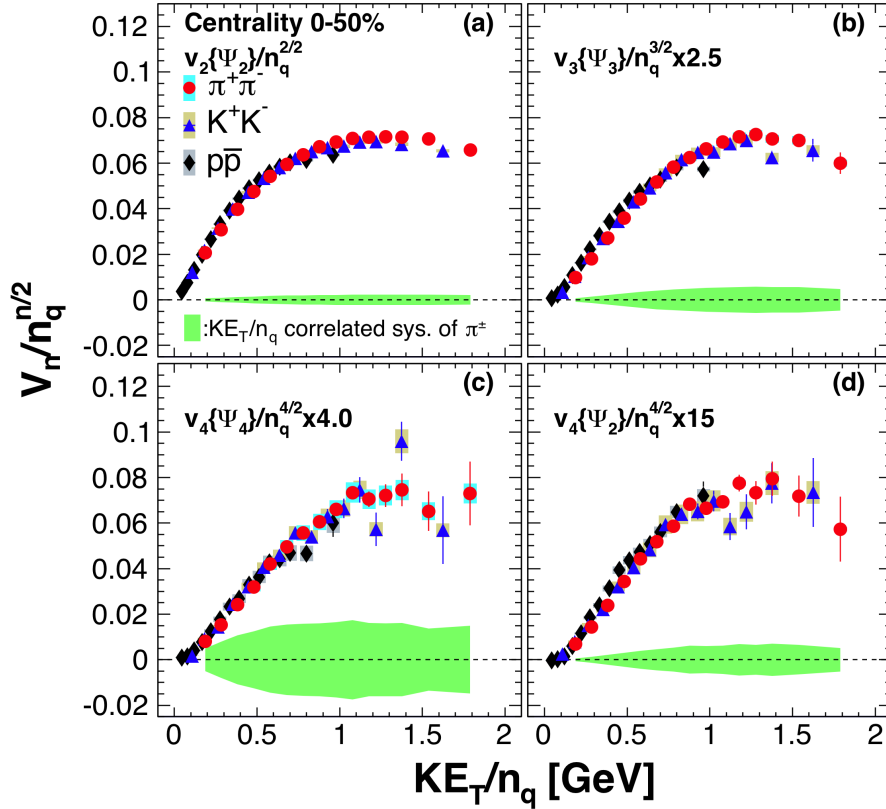
Flow in large systems



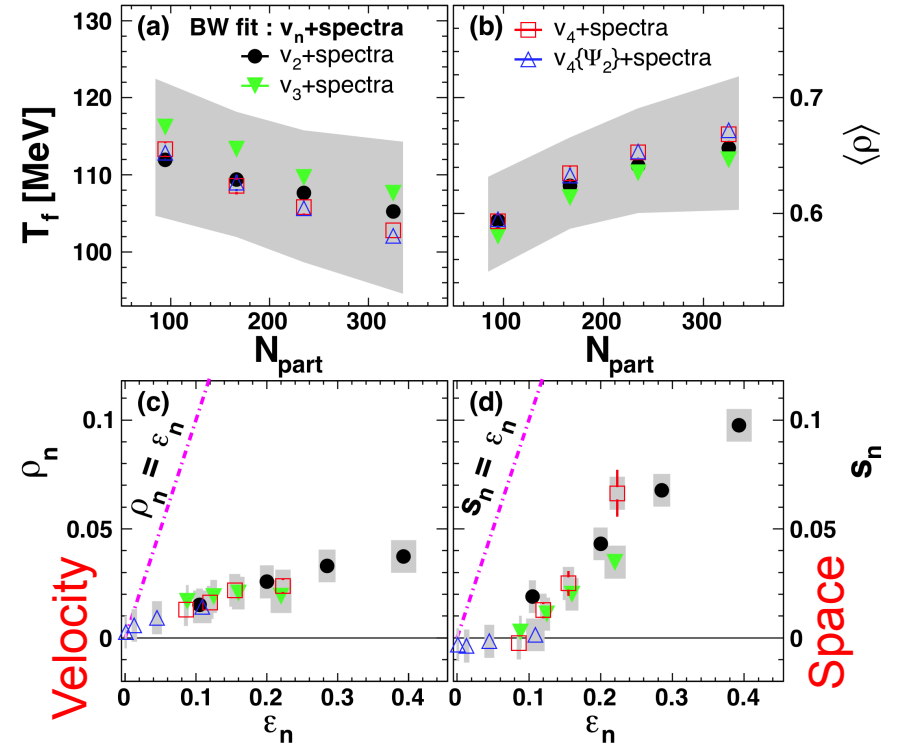
Basic survey of $v_{2,3,4}$ for identified π, K, p in Au+Au

arXiv:1412.1038

Flow in large systems



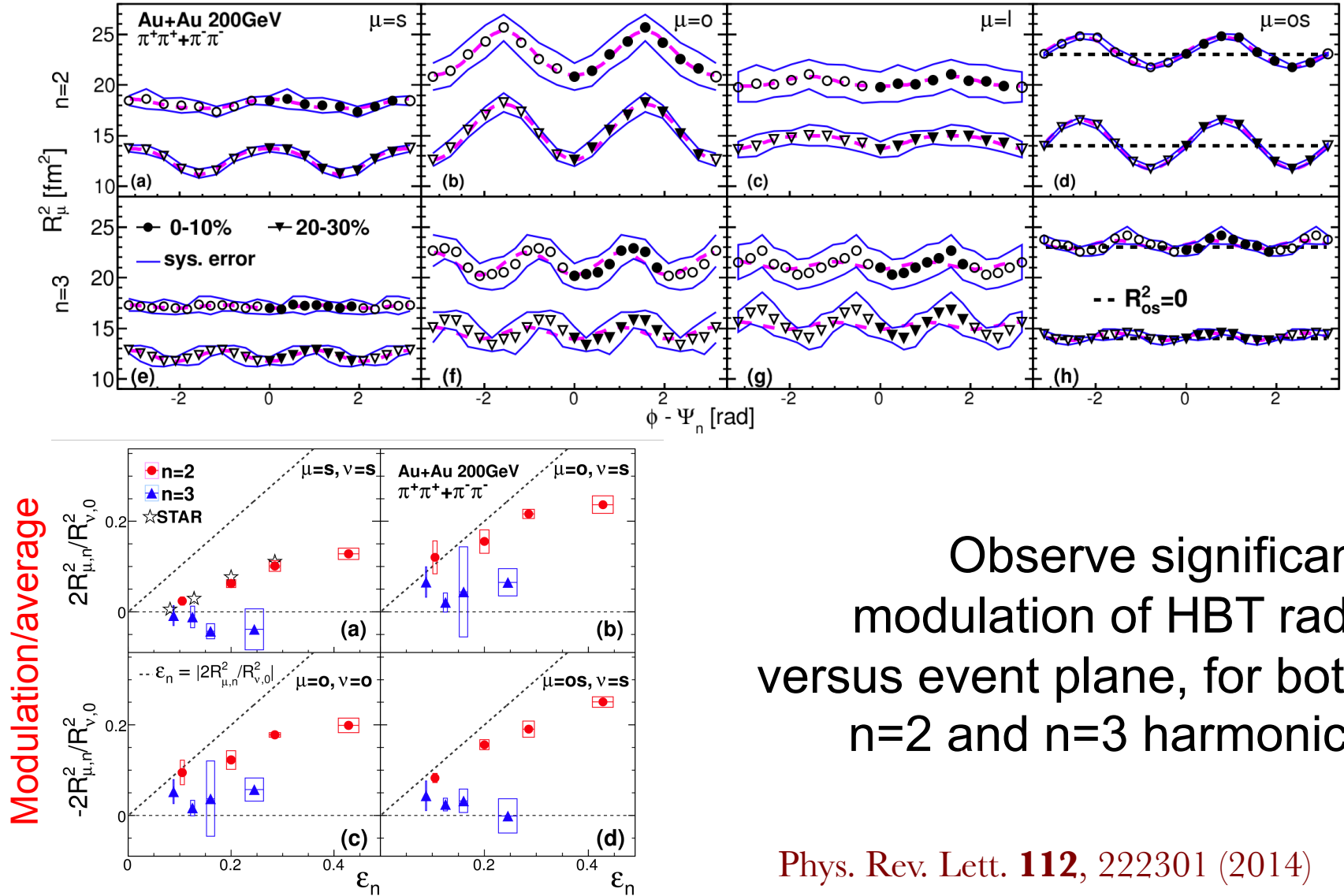
Extended quark number
scaling for $v_{2,3,4}$



Blast waves with momentum
and spatial anisotropies

arXiv:1412.1038

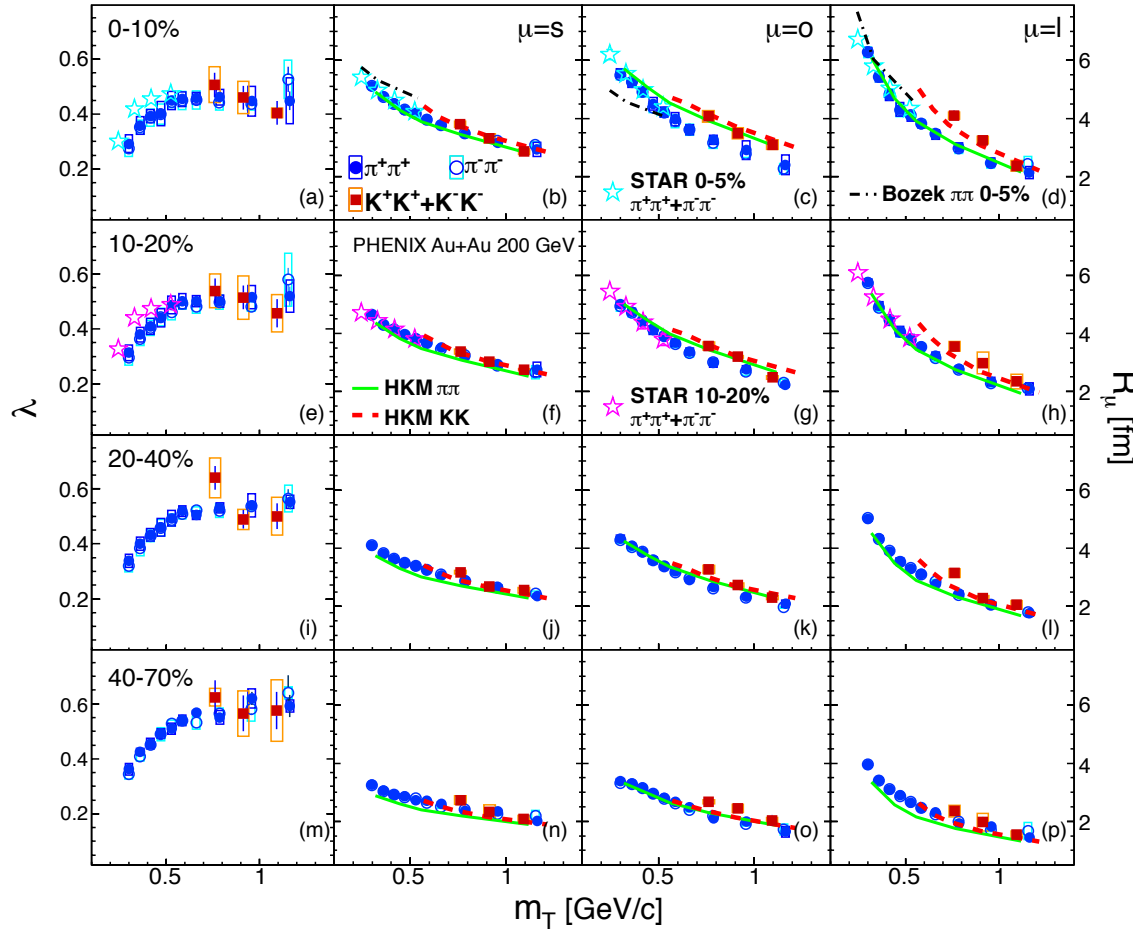
Flow *and* HBT in large systems



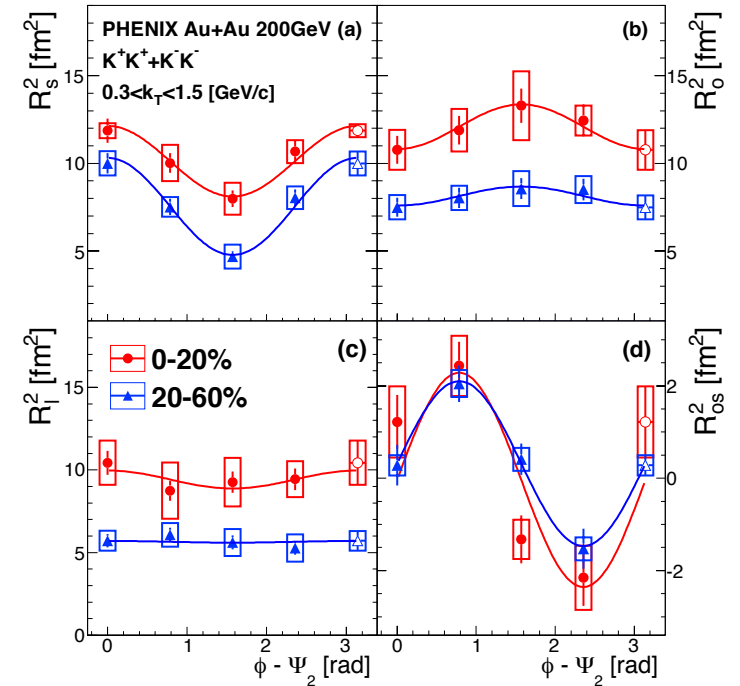
Observe significant modulation of HBT radii versus event plane, for both $n=2$ and $n=3$ harmonics

Phys. Rev. Lett. **112**, 222301 (2014)

Kaon vs pion HBT in Au+Au



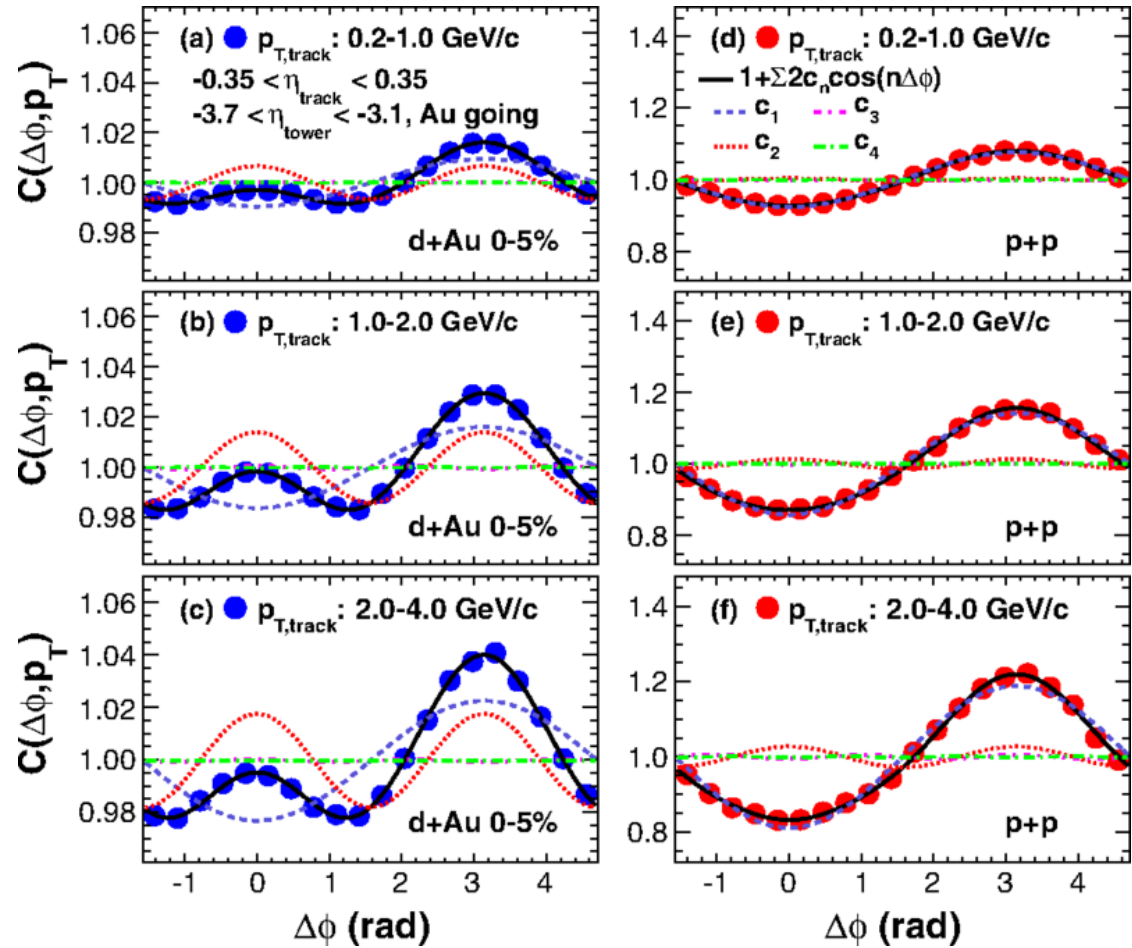
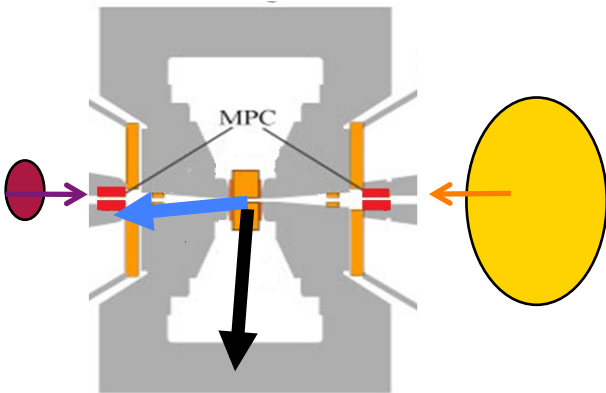
arXiv:1504.05168



Extended to higher m_T , kaon radii slightly larger than for pions; see distinct azimuthal modulation in kaon radii

Long-range correlations in d+Au

PRL
“Editor’s Choice”
highlight

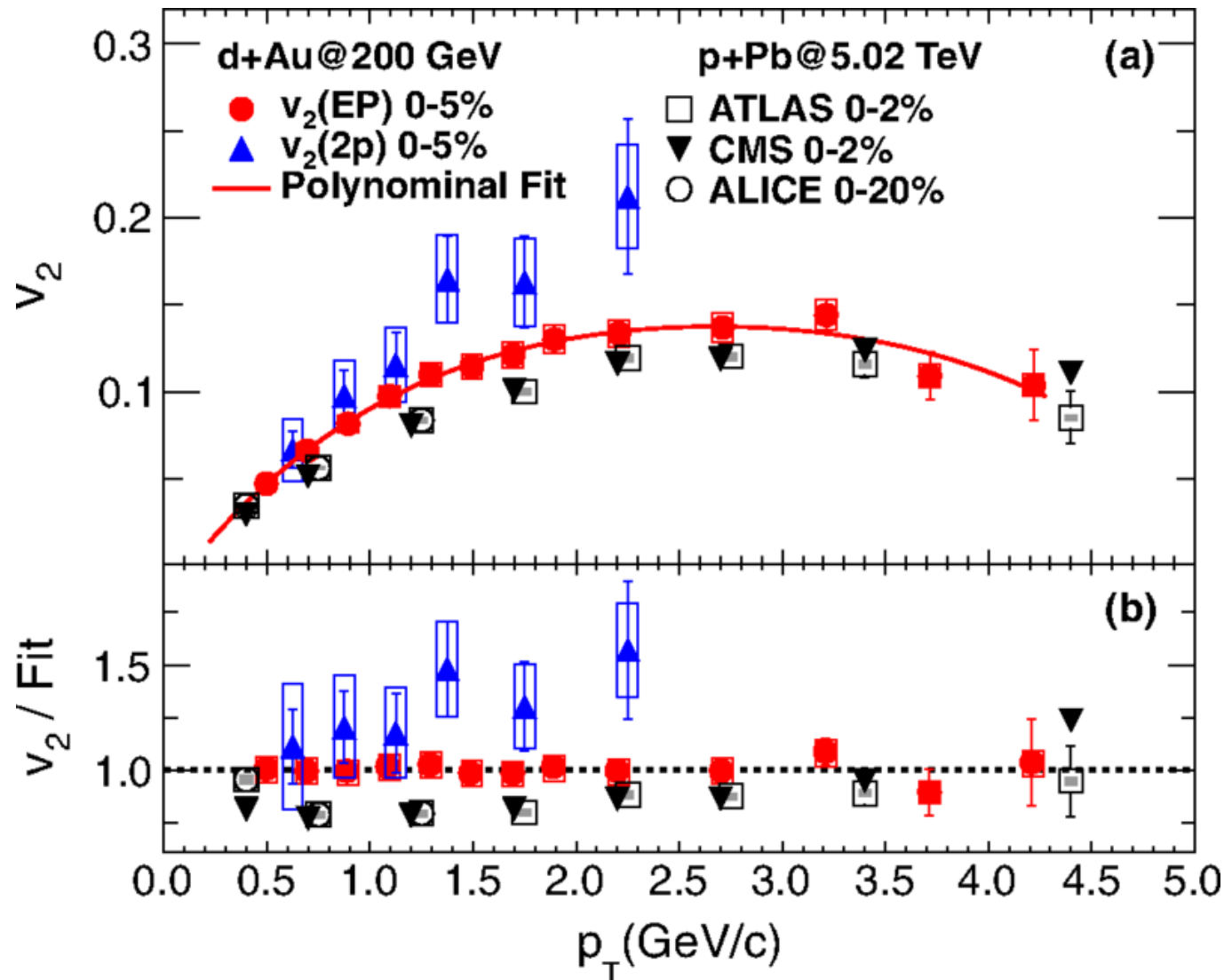


d+Au 0-5%

p+p min-bias

Phys. Rev. Lett. **114**, 192301 (2015)

$v_2(\text{EP})$ of charged hadron in 0-5% d+Au

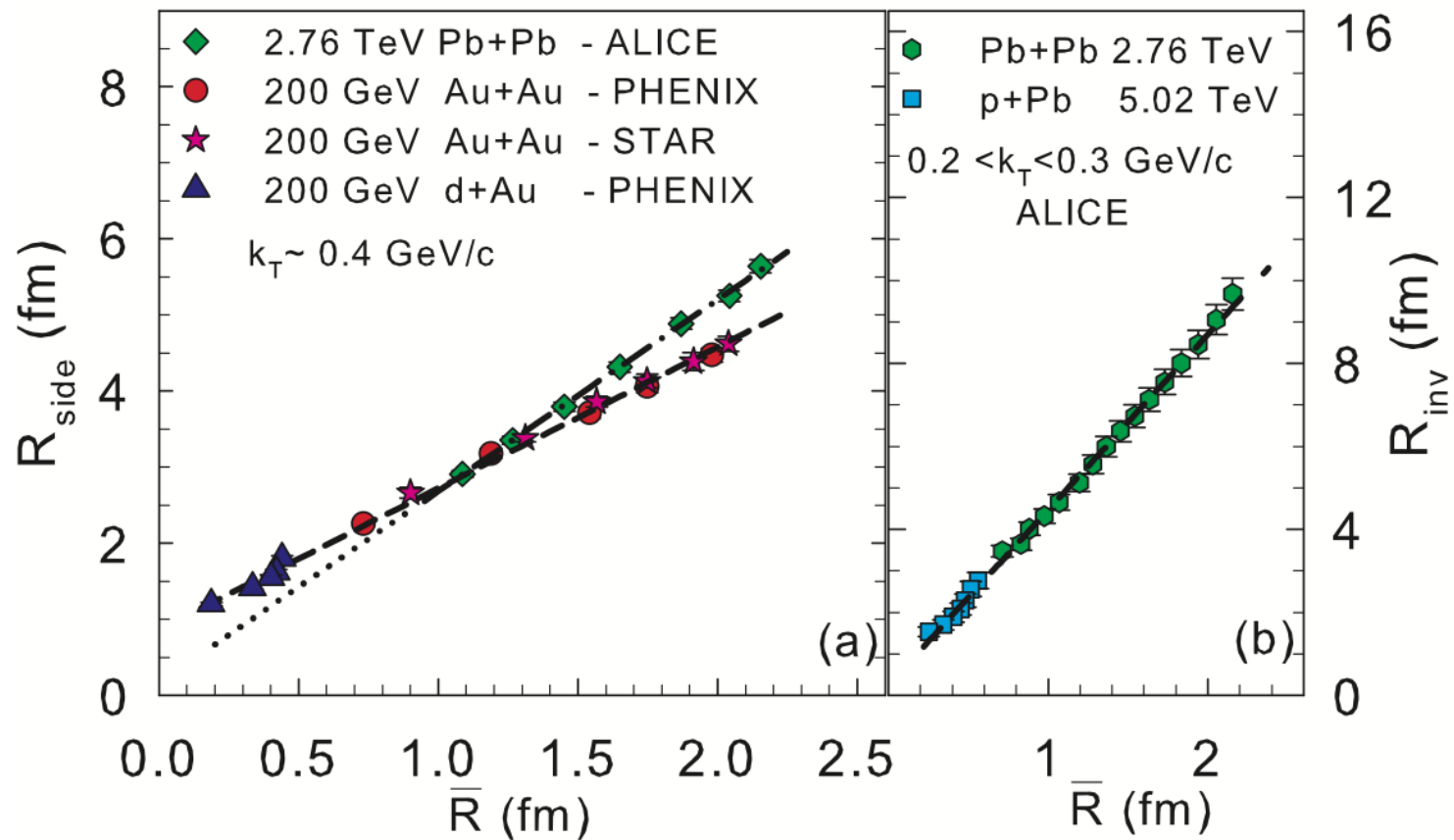


Hydro-like
shape in
 $v_2(p_T)$?

No visible v_3
over long
range, unlike
LHC p+Pb.

HBT in small systems

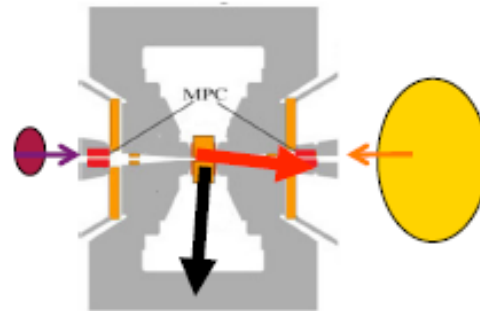
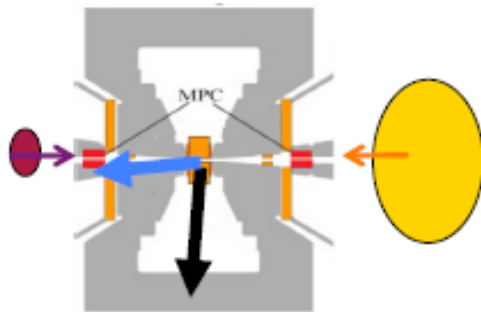
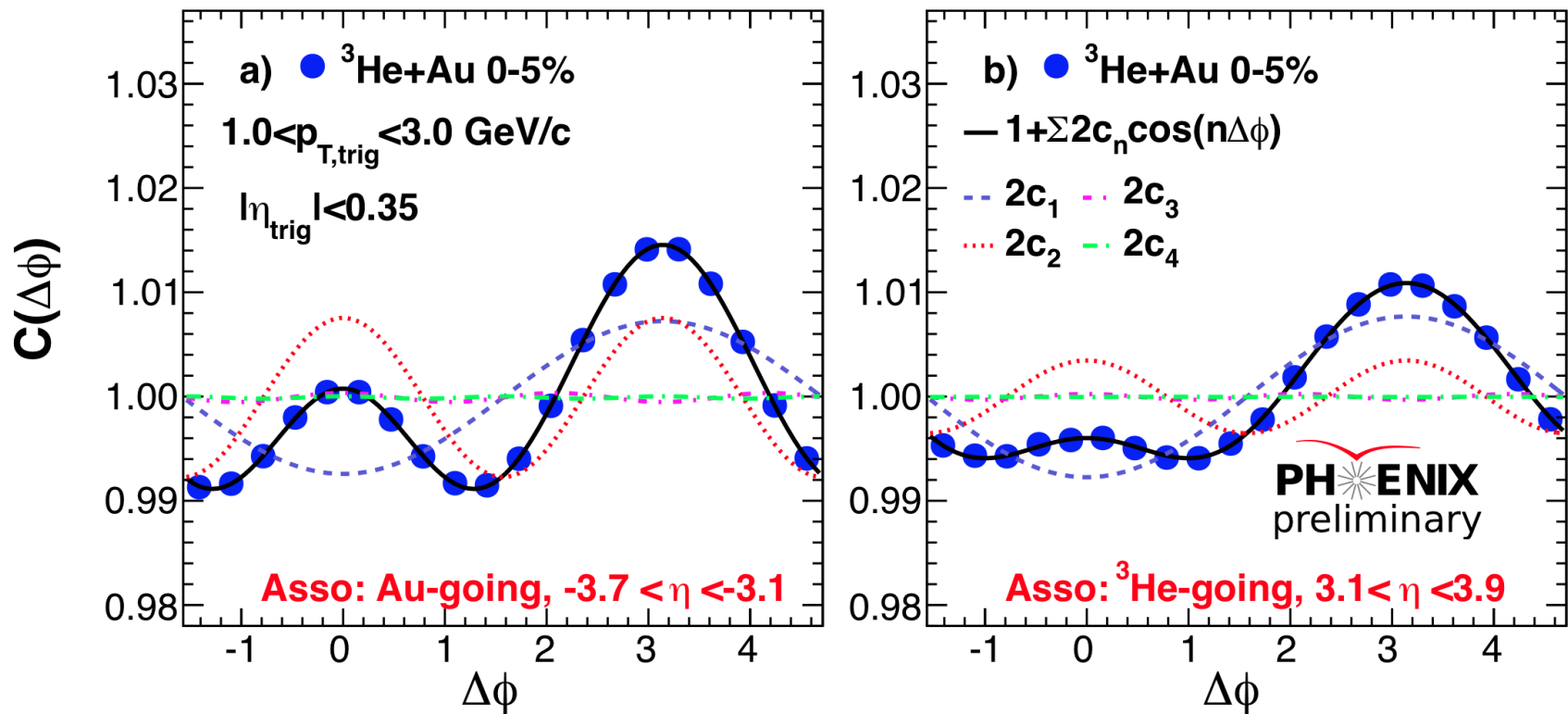
Perfectly smooth continuum between d+Au, Au+Au systems; also p+Pb and Pb+Pb



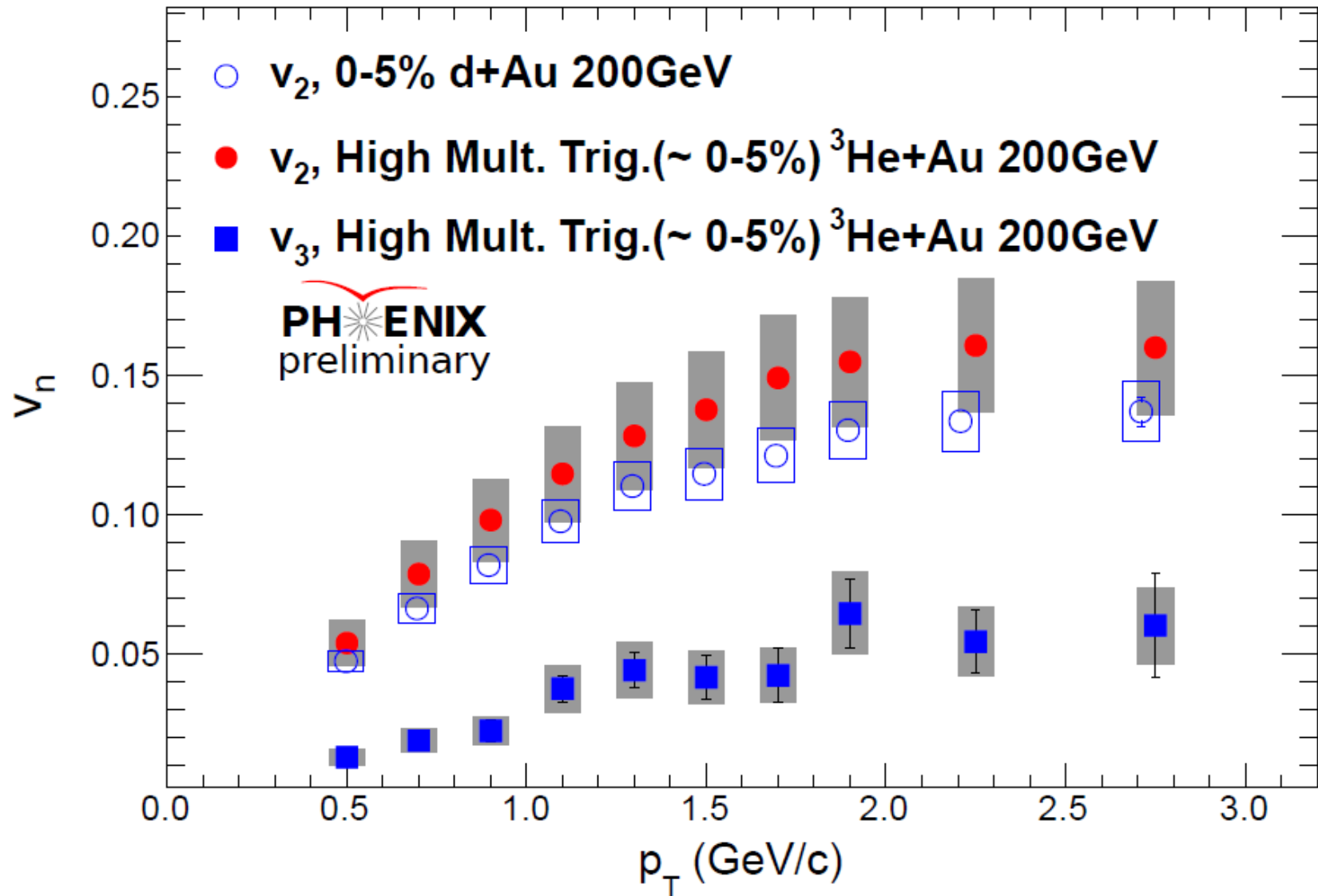
arXiv:1404.5291

$$1/\bar{R} = \sqrt{(1/\sigma_x^2 + 1/\sigma_y^2)} \quad \leftarrow \text{Initial state size parameter}$$

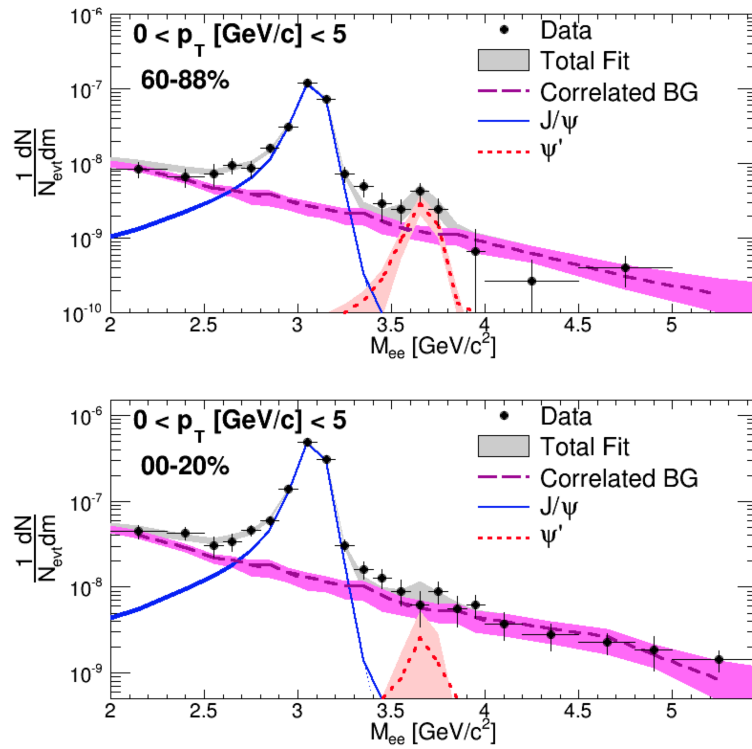
Long-range correlation in $^3\text{He}+\text{Au}$



Azimuthal flow, $v_{2,3}$ in $^3\text{He}+\text{Au}$

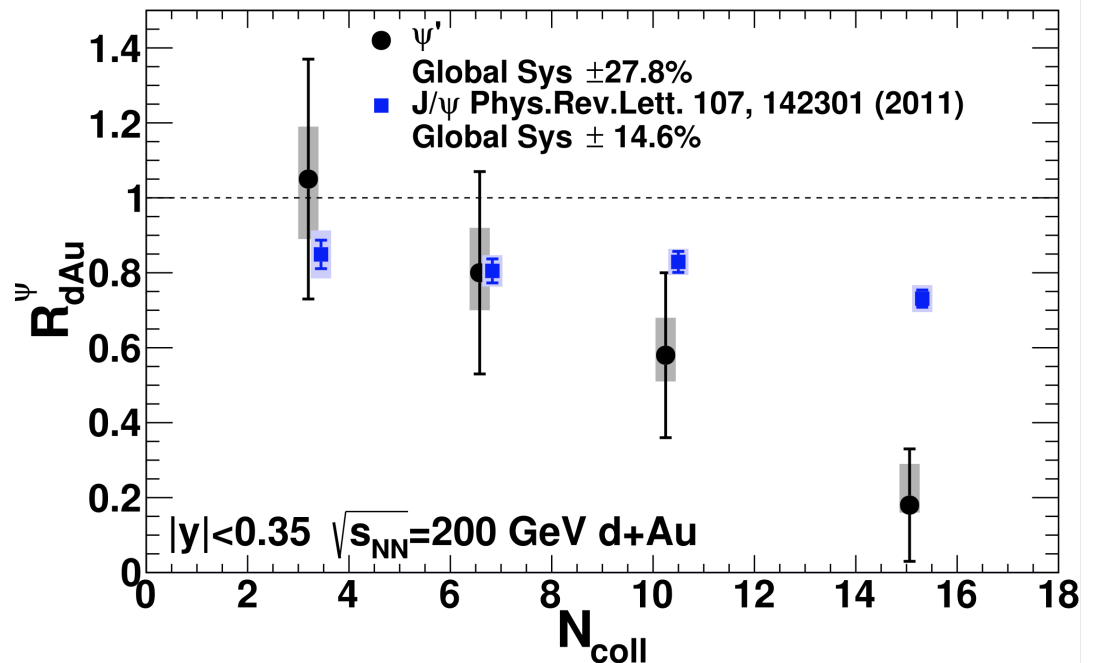
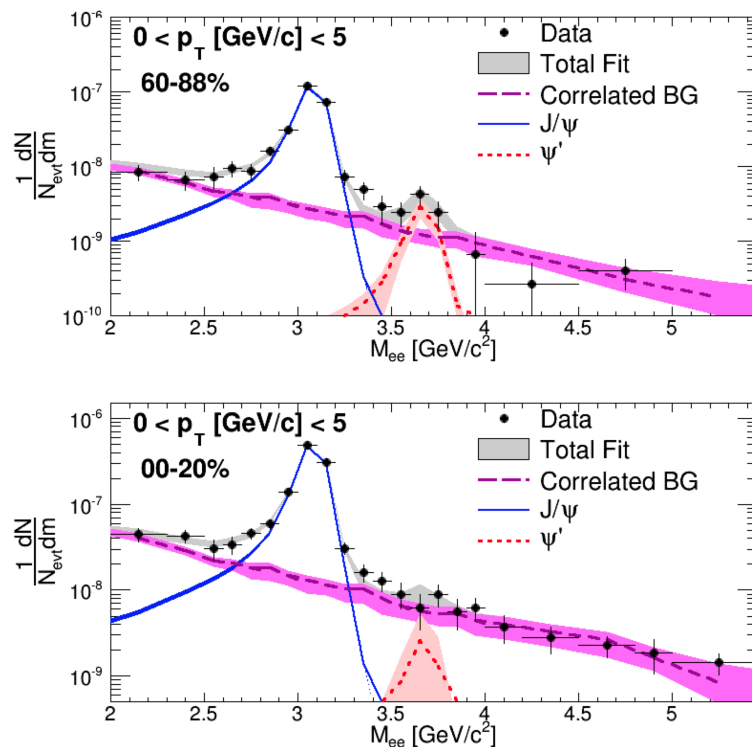


Heavy flavor in d+Au



PRL **111**, 202301 (2013)

Psi' (over?) suppression in d+Au

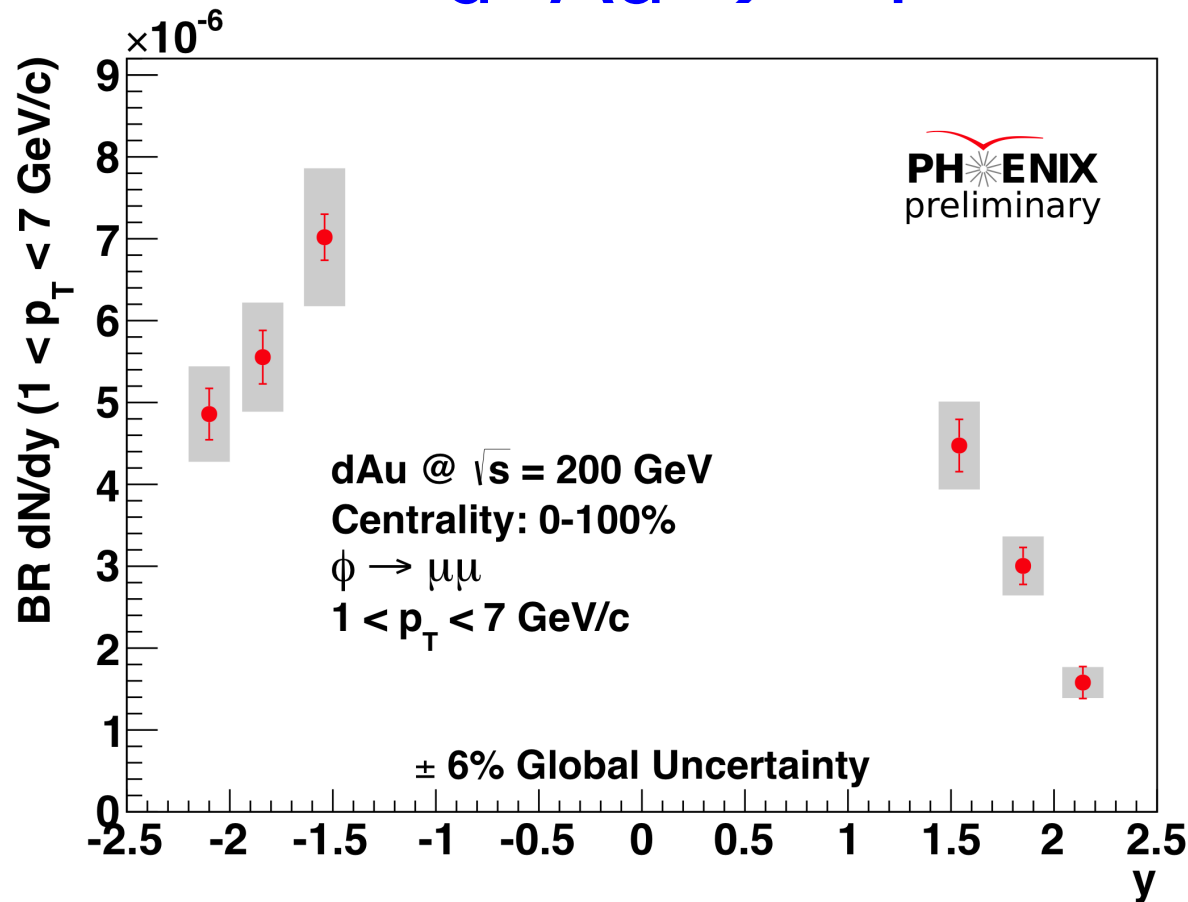


Relative suppression of Psi'
compared to J/Psi – is it a
created medium effect?
(Also seen by ALICE in p+Pb)

PRL **111**, 202301 (2013)

Sort-of-heavy flavor in d+Au

d+Au \rightarrow Φ

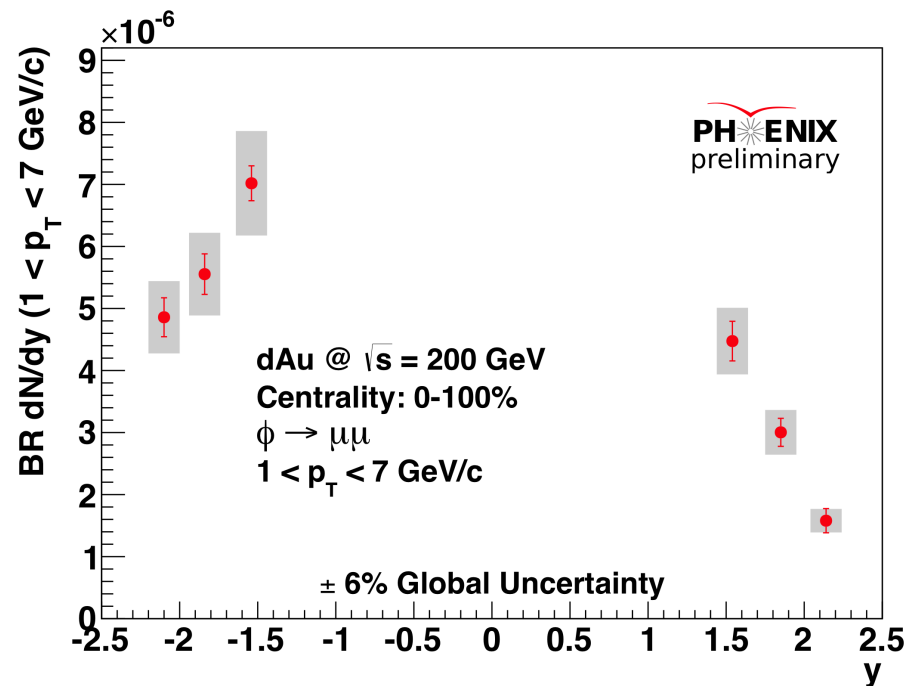


Production of Φ in d+Au shows significant forward/backward asymmetry

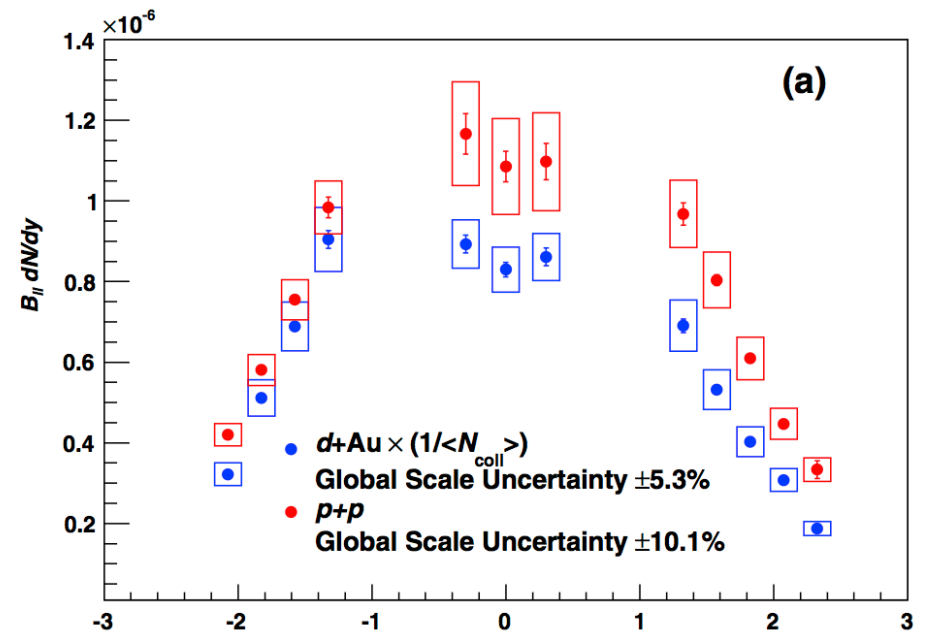
What physics controls this?

Sort-of-heavy flavor in d+Au

d+Au \rightarrow ϕ

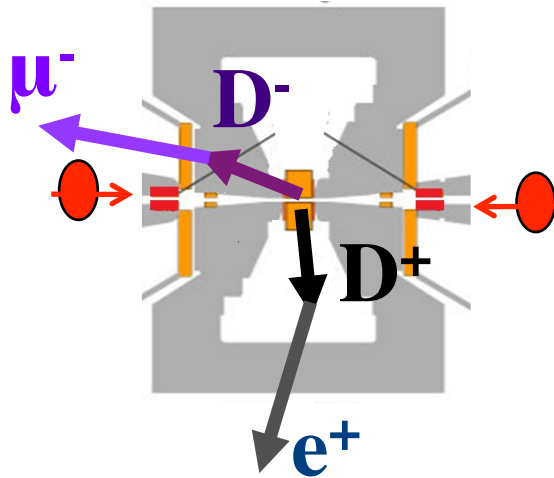


d+Au \rightarrow J/ ψ

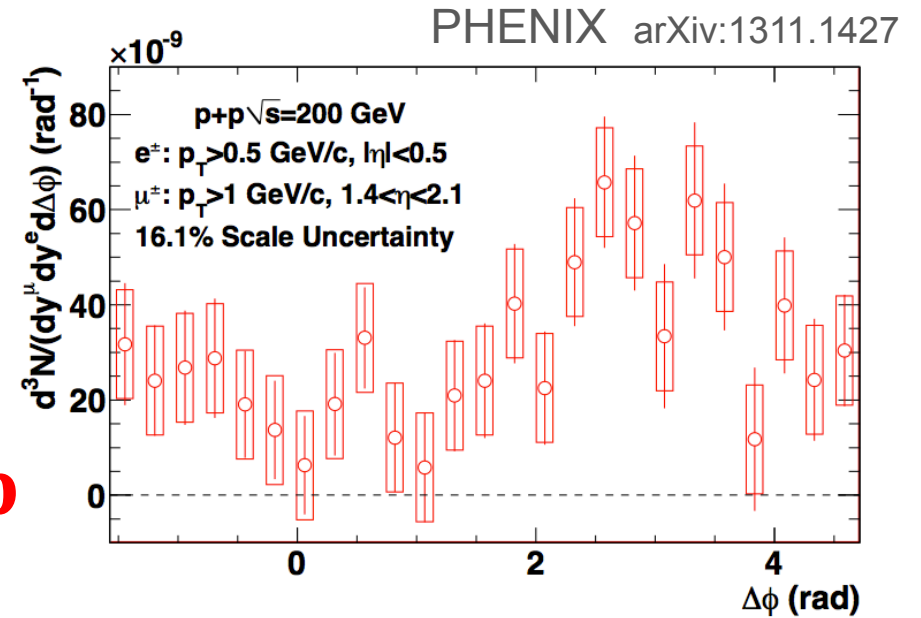


PRL **107**, 142301 (2011)

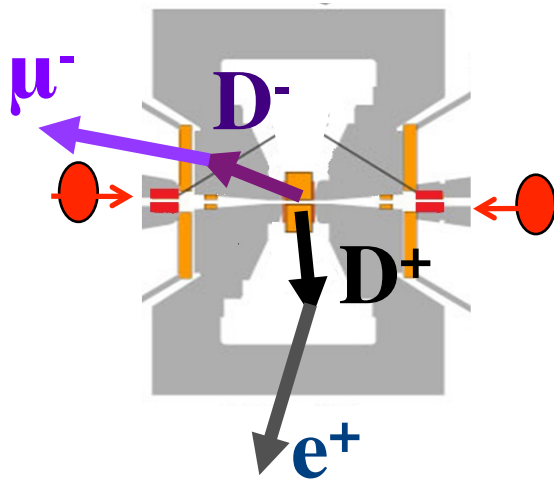
Open charm de-correlation



p+p

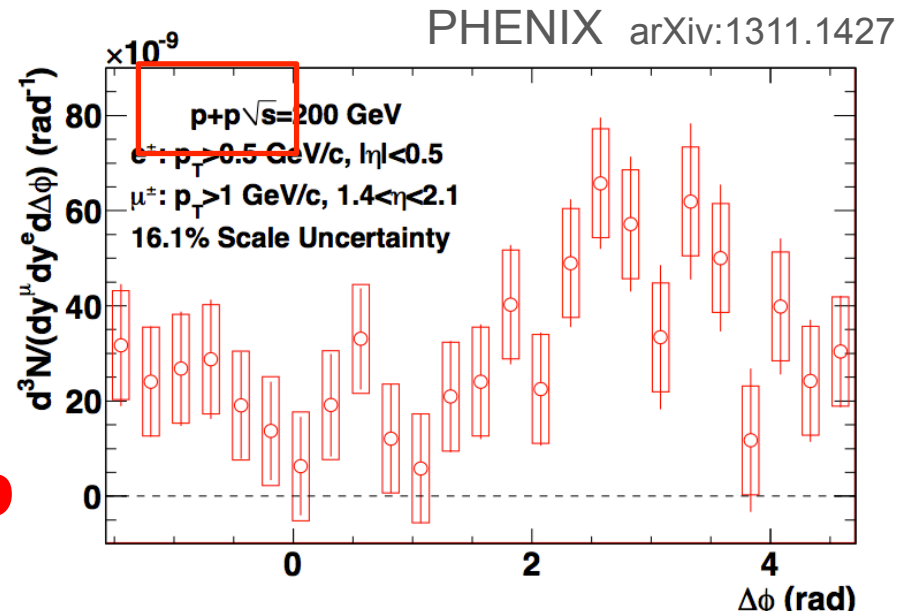


Open charm de-correlation

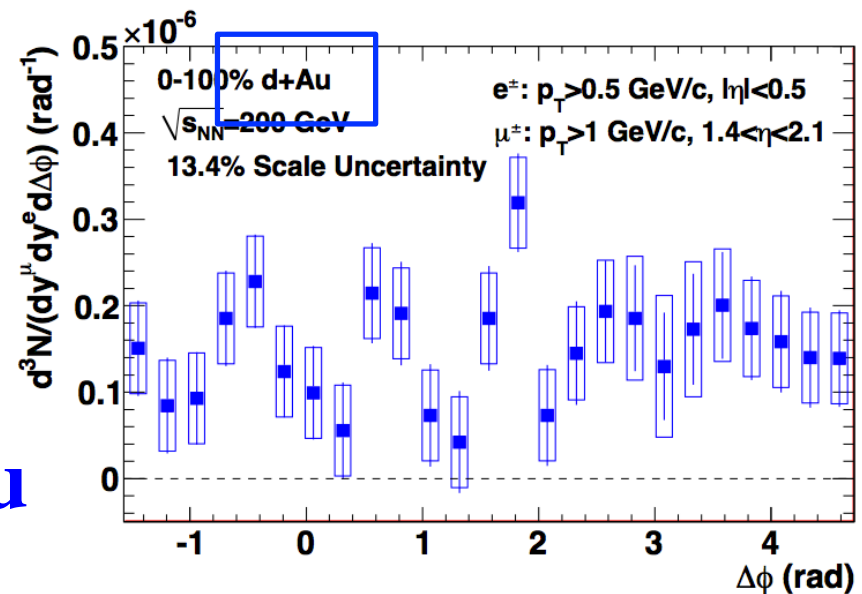


Back-to-back correlation of associated charm is decreased in d+Au; what is the site of any re-scattering?

p+p



d+Au

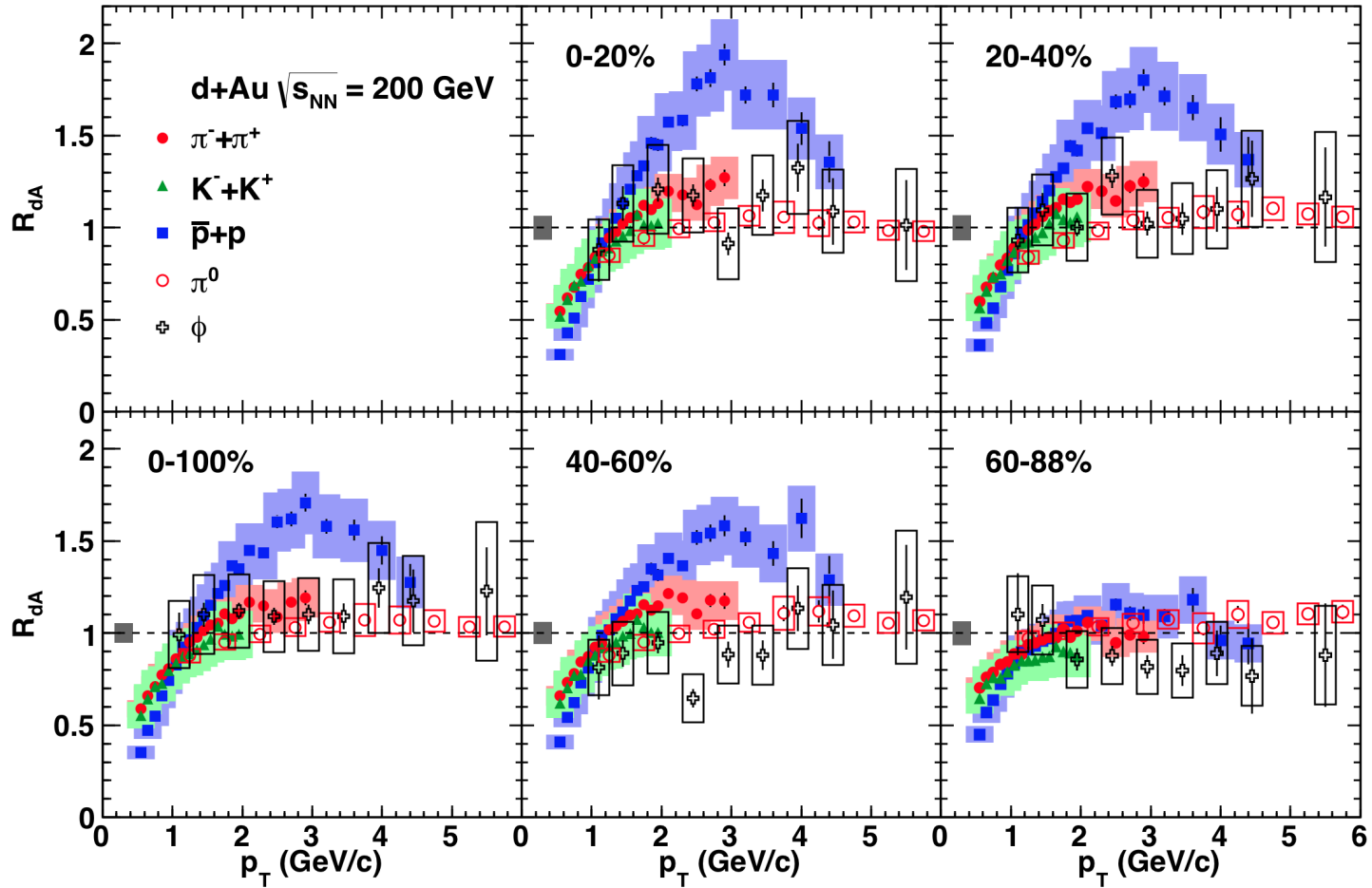


Summary

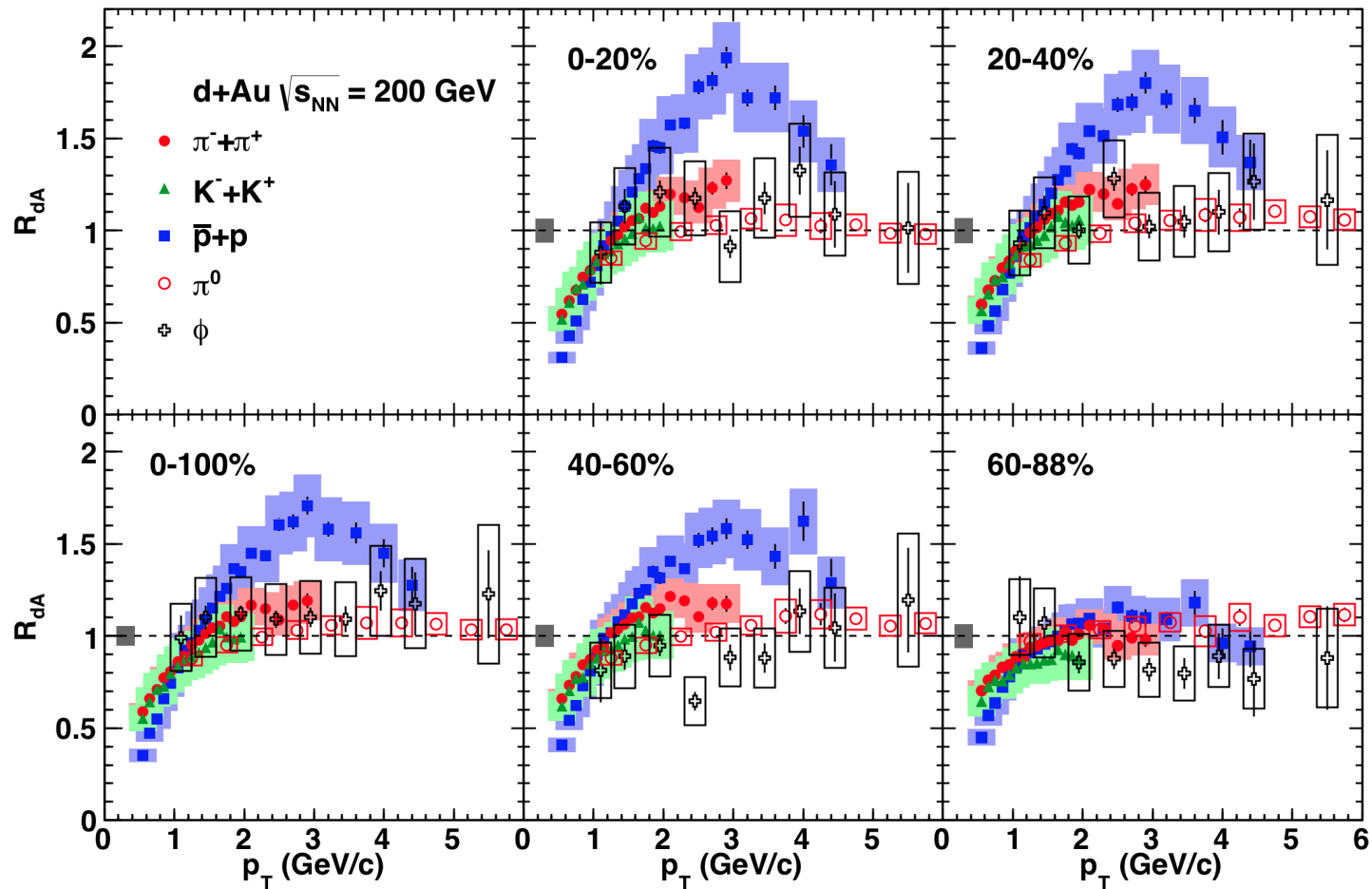
- Extensive data sets on final-state anisotropies in Au+Au; PID hadrons $v_{2,3,4}$ and HBT
- Flow/collectivity signatures in small systems continue to accumulate
 - new: v_3 in $^3\text{He}+\text{Au}$, v_2 similar to d+Au
 - HBT continuous from d+Au to Au+Au
- New effects on heavy flavor in d+Au

Backup material

Light hadrons Cronin rides again?

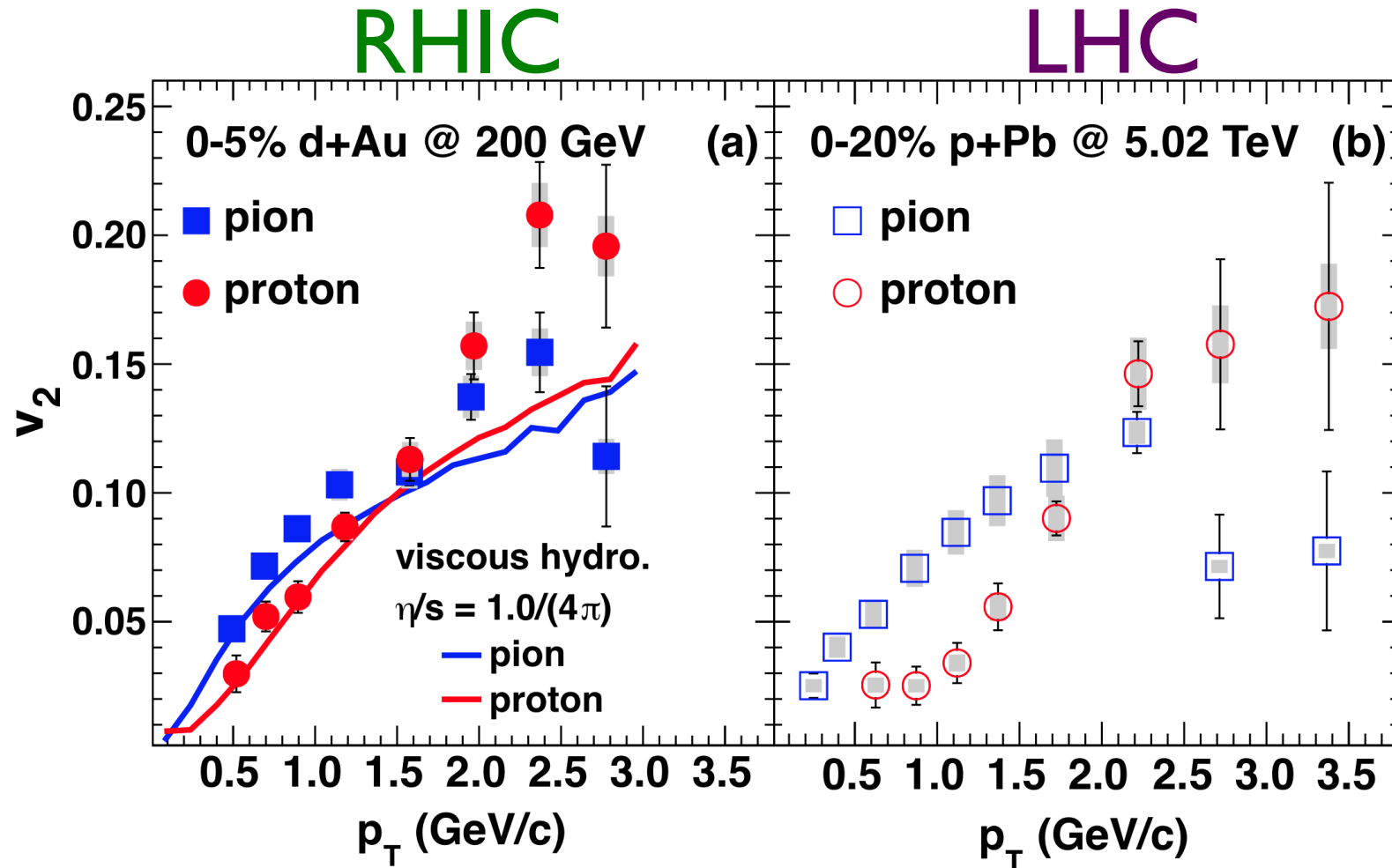


Light hadrons Cronin rides again?



Dramatic baryon enhancement: recombination
from a medium?

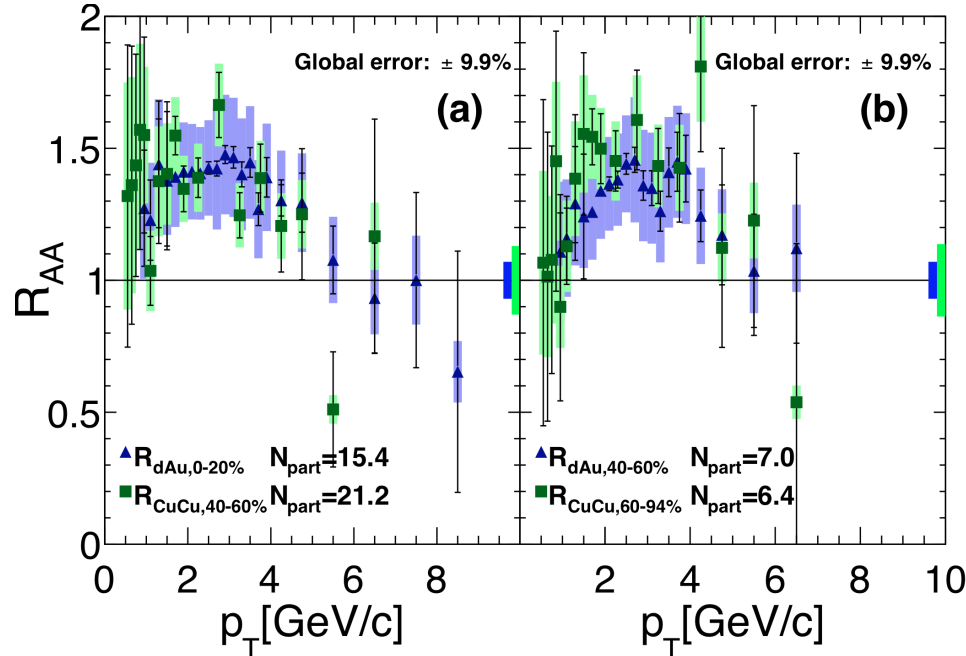
Mass splitting of v_2 (EP)



Charm boost follows N_{Part}

Heavy-flavor electrons in three systems

d+Au meets Cu+Cu

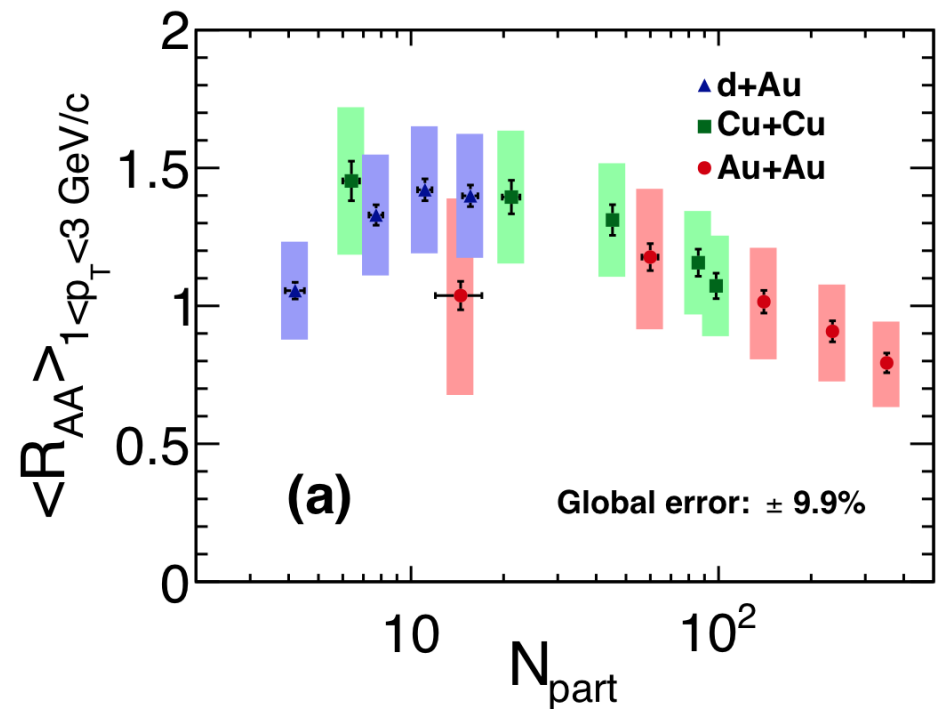
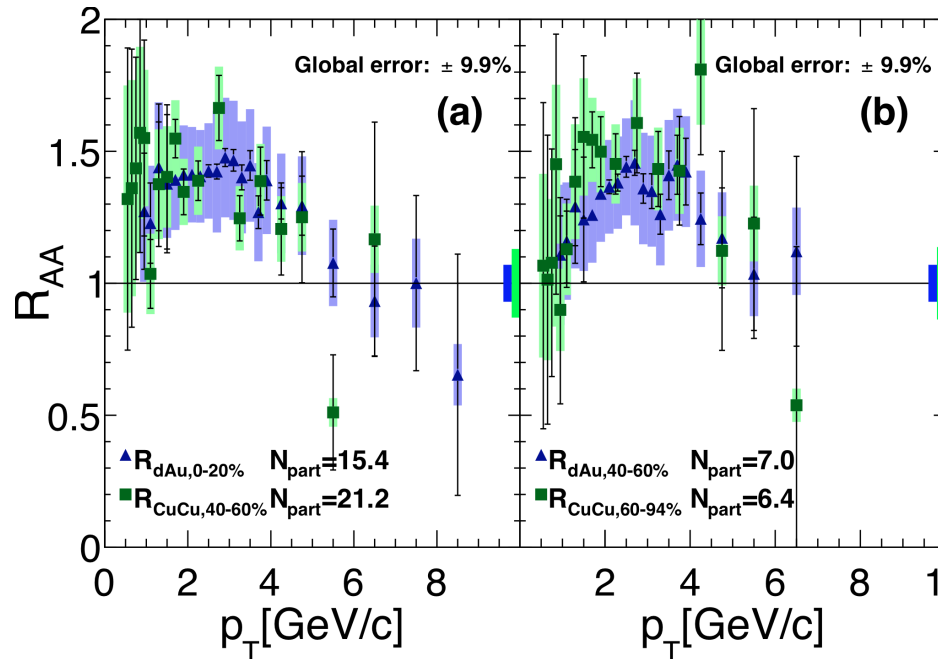


arXiv:1310.8286

Charm boost follows N_{Part}

Heavy-flavor electrons in three systems

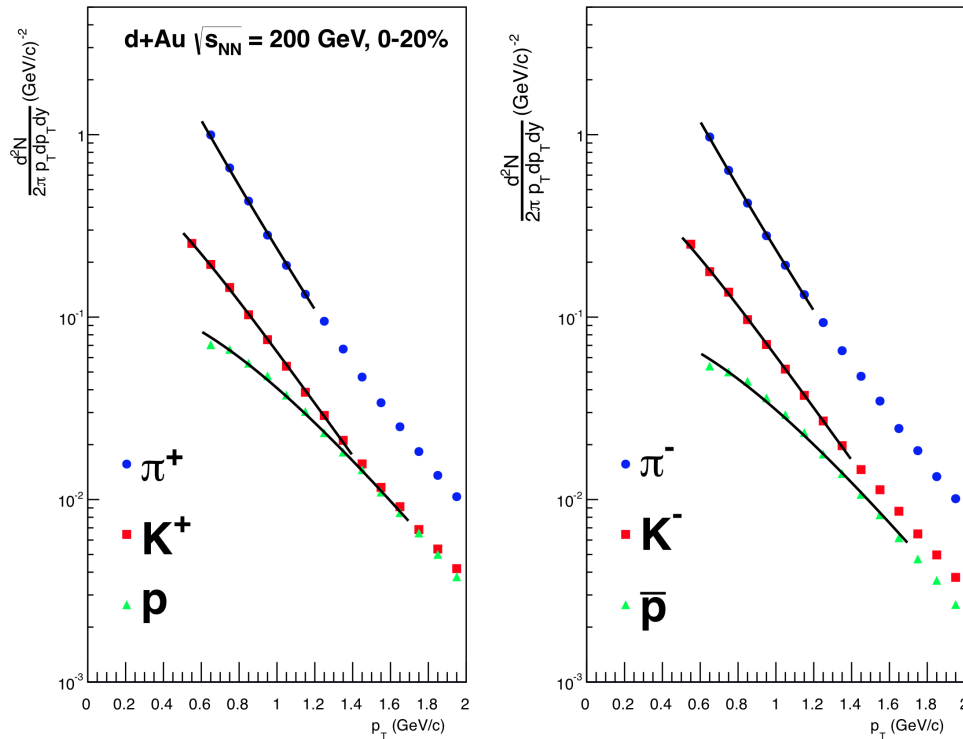
d+Au meets Cu+Cu



arXiv:1310.8286

Single charm is pushed but never destroyed; is trend with N_{part} indicative of medium effect?

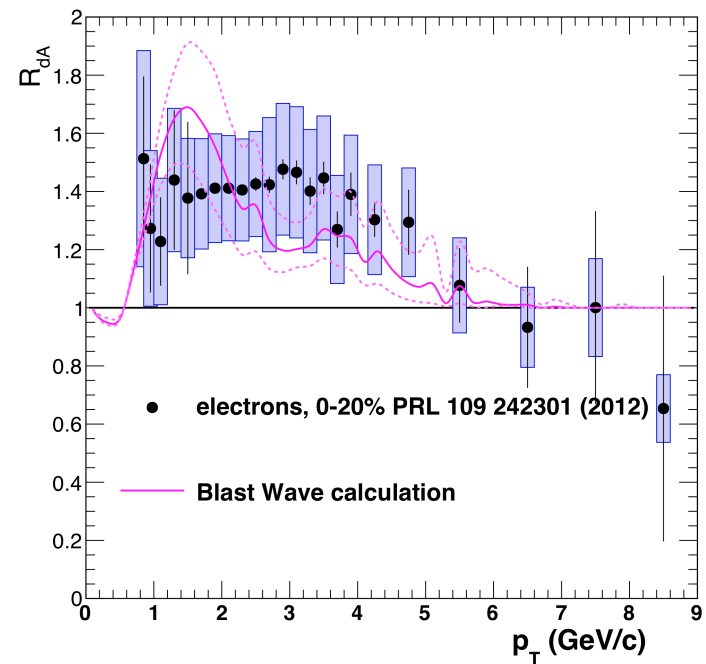
Radial flow in d+Au?



**Blast-wave fits to identified
light hadron spectra**

A. Sickles, Phys. Lett. B731 51-56 (2014),
“Possible Evidence for Radial Flow of
Heavy Mesons in d+Au Collisions”

Was it the source of
the Cronin effect?



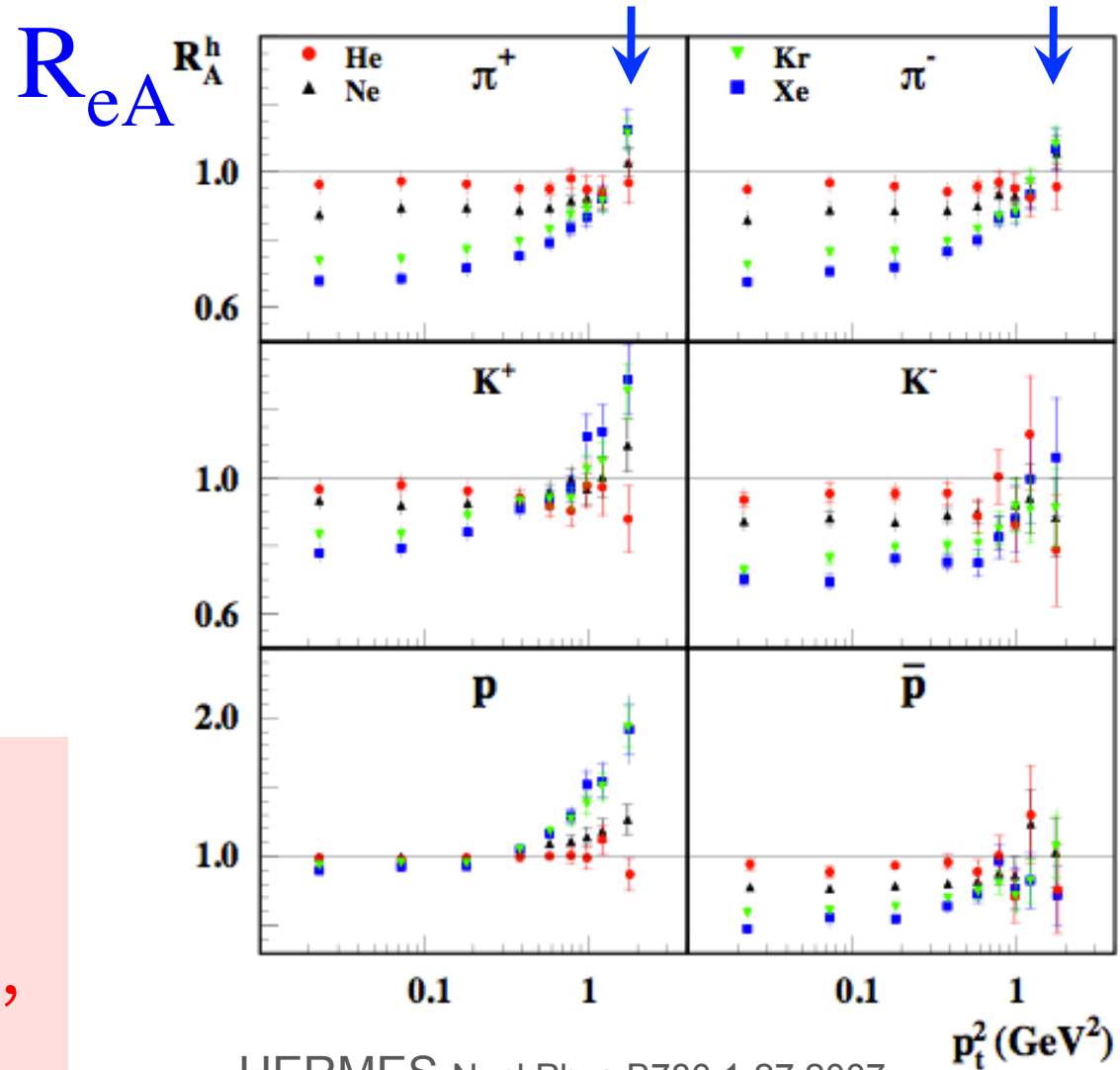
**Heavy-flavor (charm)
electron R_{dAu}**

Caution: Cronin rides in $e+A$

Enhancement of
(+) hadron yields at
 $p_T \sim 1\text{--}1.5 \text{ GeV}/c$
is seen with
increasing A in $e+A$.

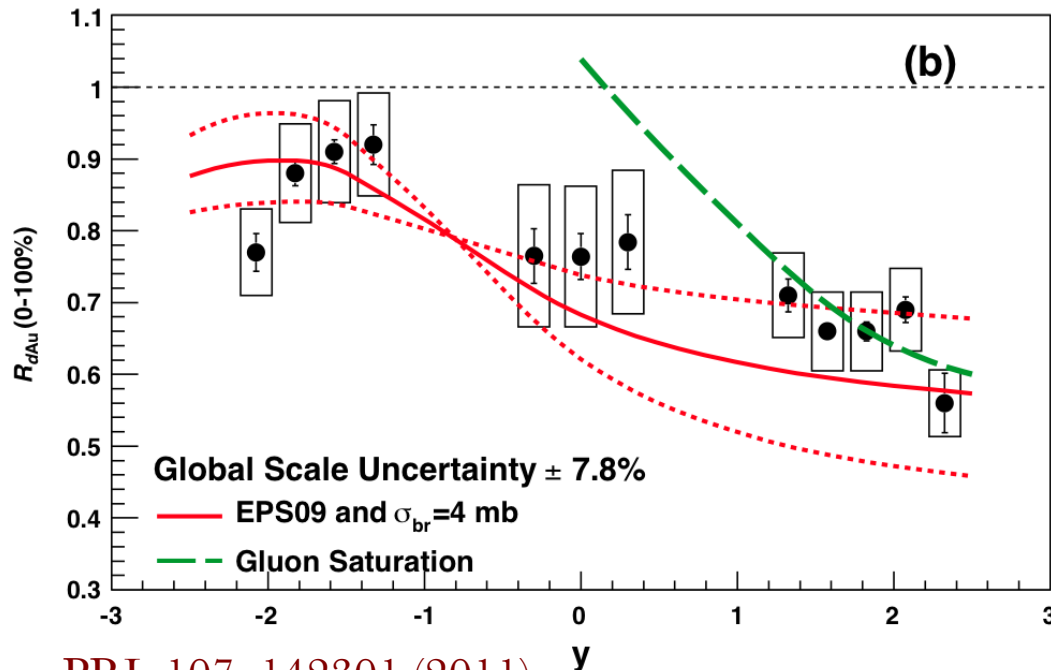
Pattern is *sort of* like
radial flow?

Moral: Need to
look at small
systems with full,
proper models



HERMES Nucl.Phys.B780:1-27,2007

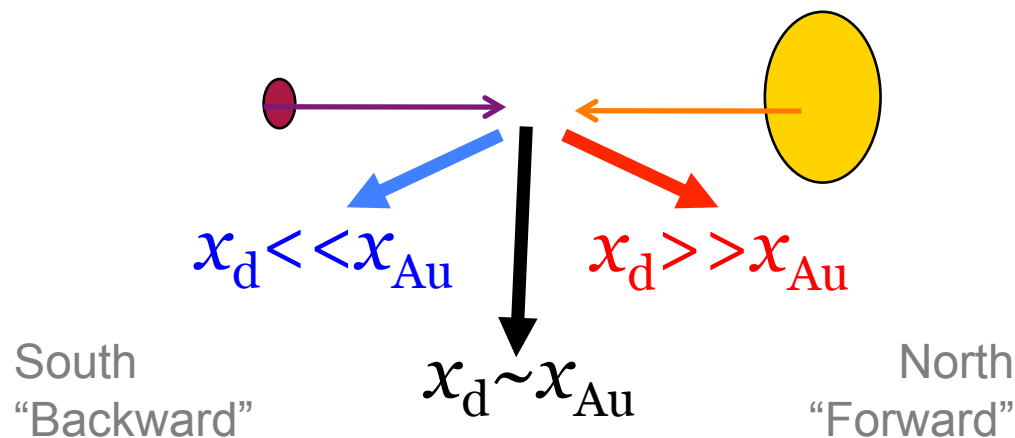
d+Au to forward/backward J/Psi



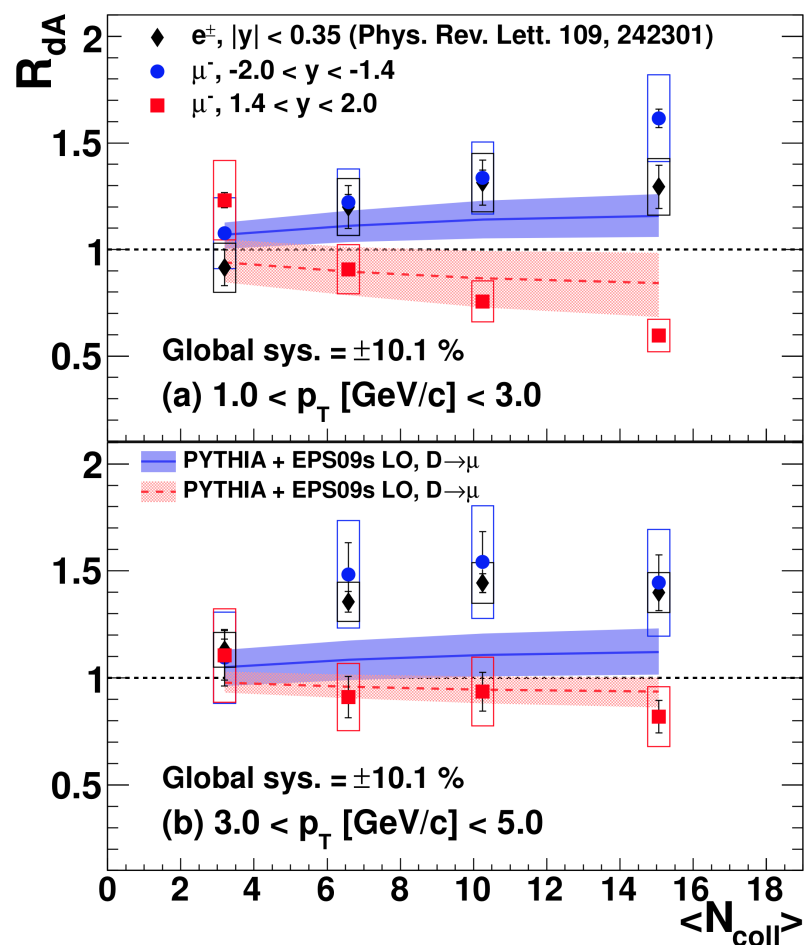
PRL 107, 142301 (2011)

R_{dAu} for J/Psi in
min-bias d+Au

For inclusive d+Au,
CNM modifications
capture forward/
backward difference
(but geometry
dependence is harder).



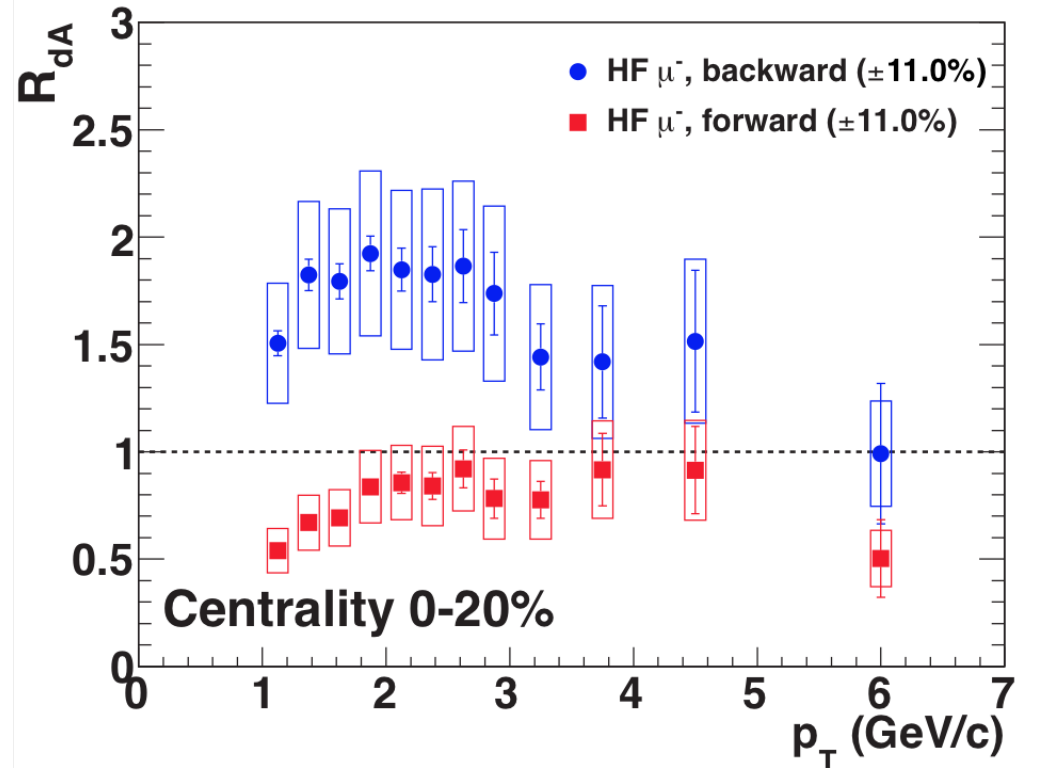
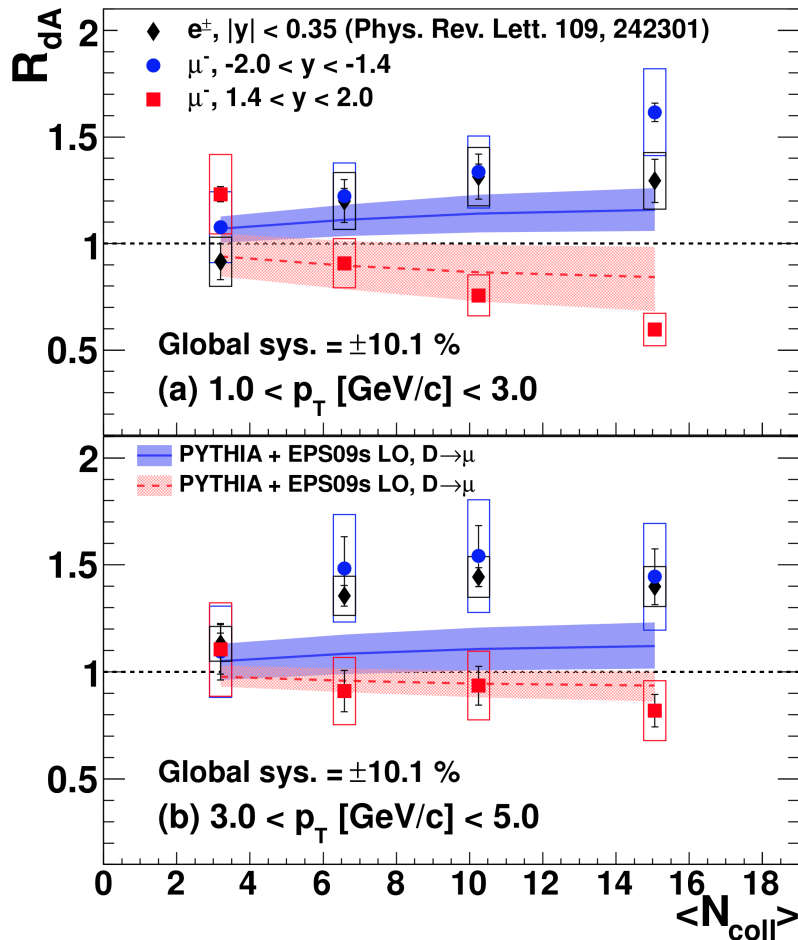
Heavy flavor leptons, forward/back



Forward-backward difference
seen, but larger than from EPS09

arXiv:1310.1005

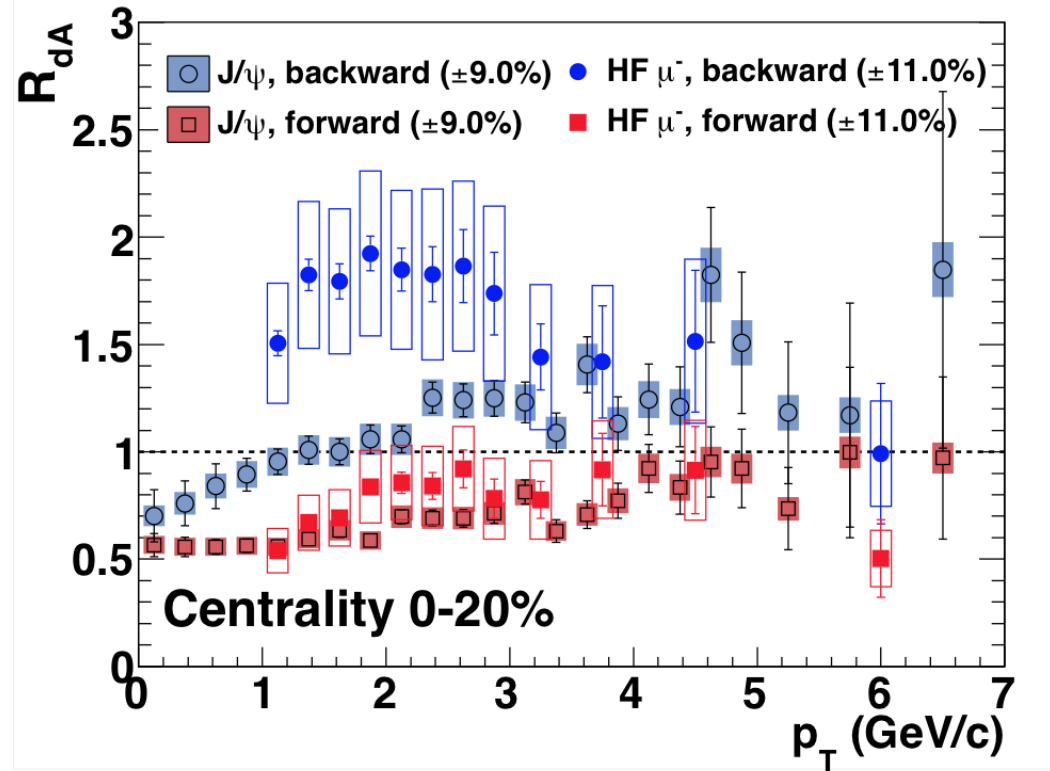
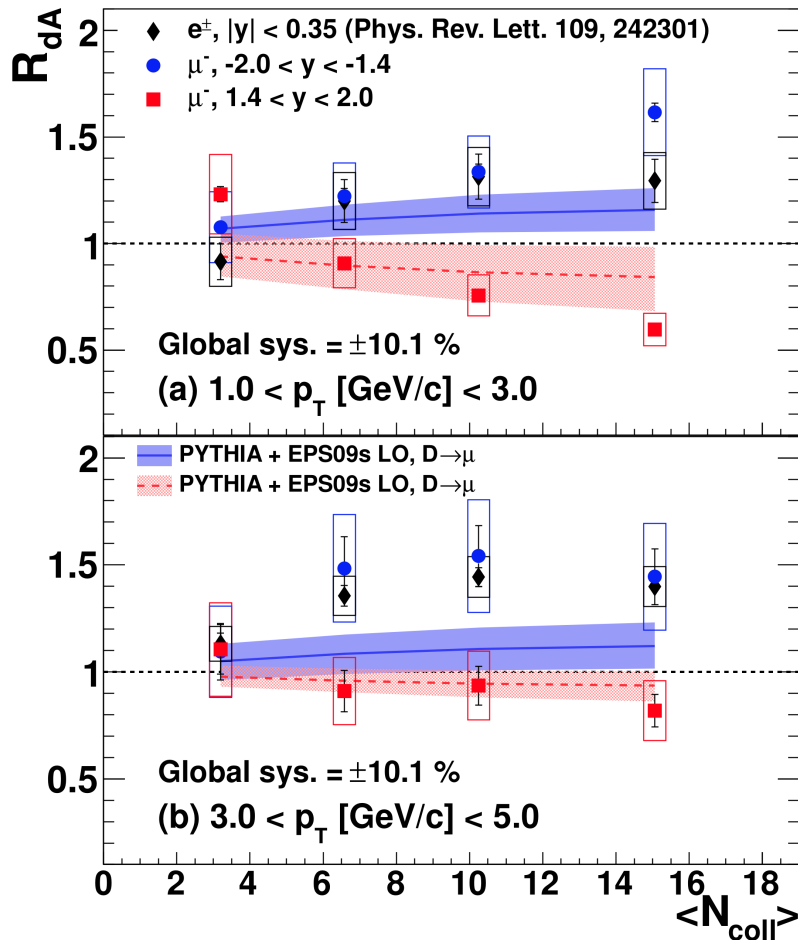
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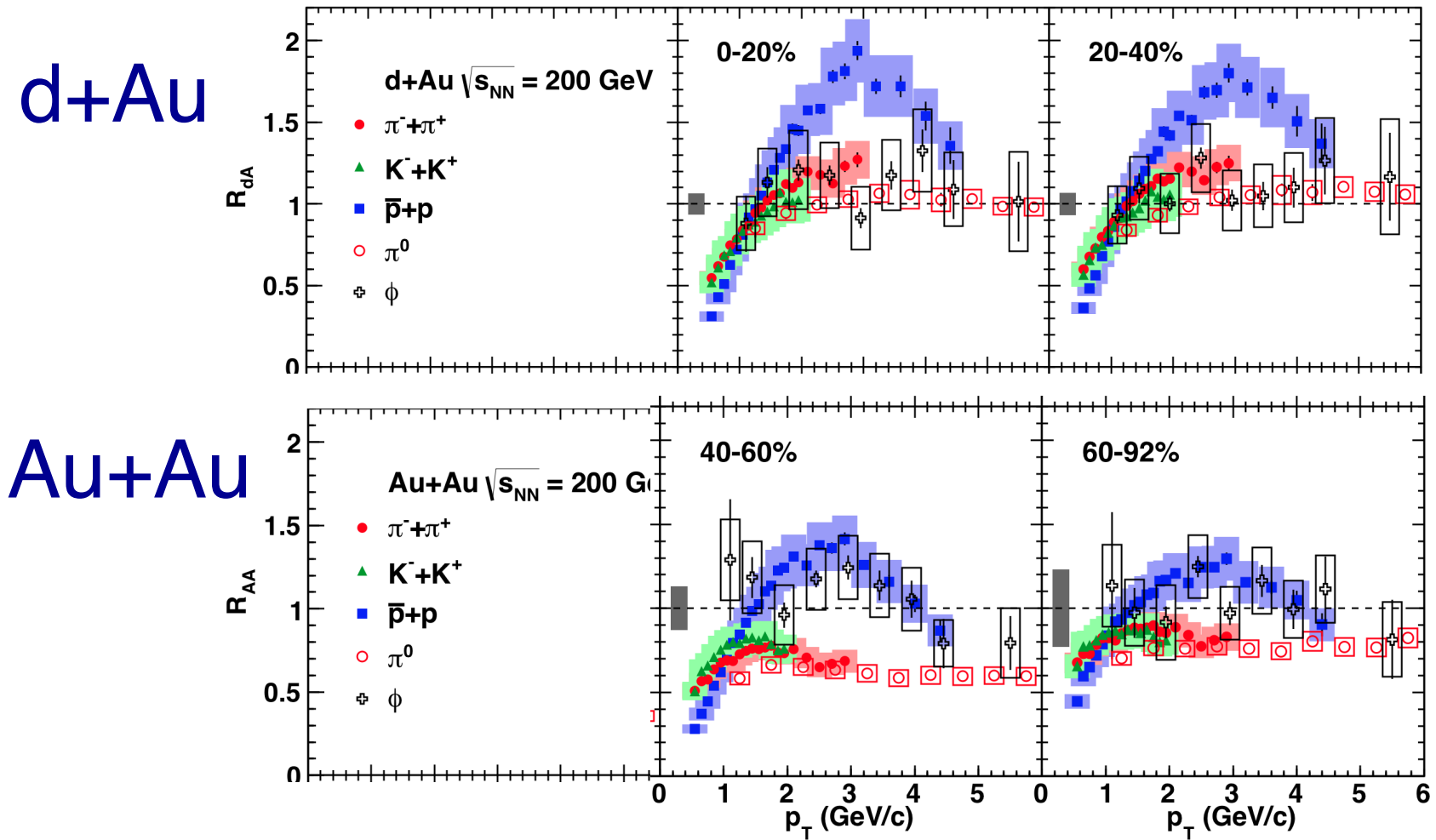
Heavy flavor leptons, forward/back



Backward, Au-going effect larger for HF than for J/Psi

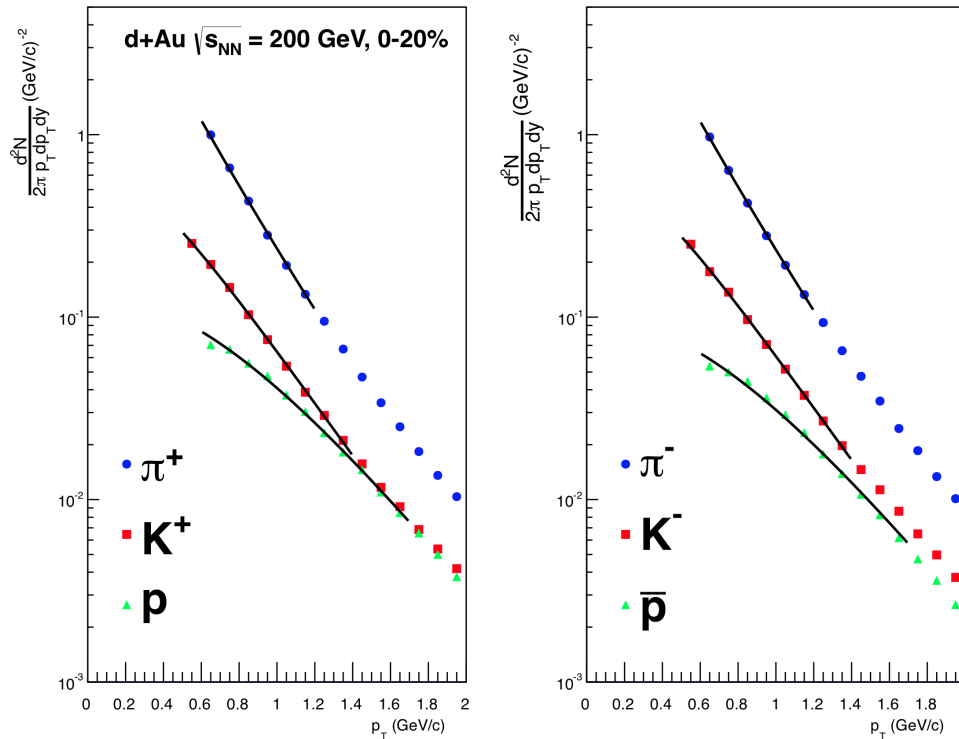
arXiv:1310.1005

Central d+Au vs Periph Au+Au



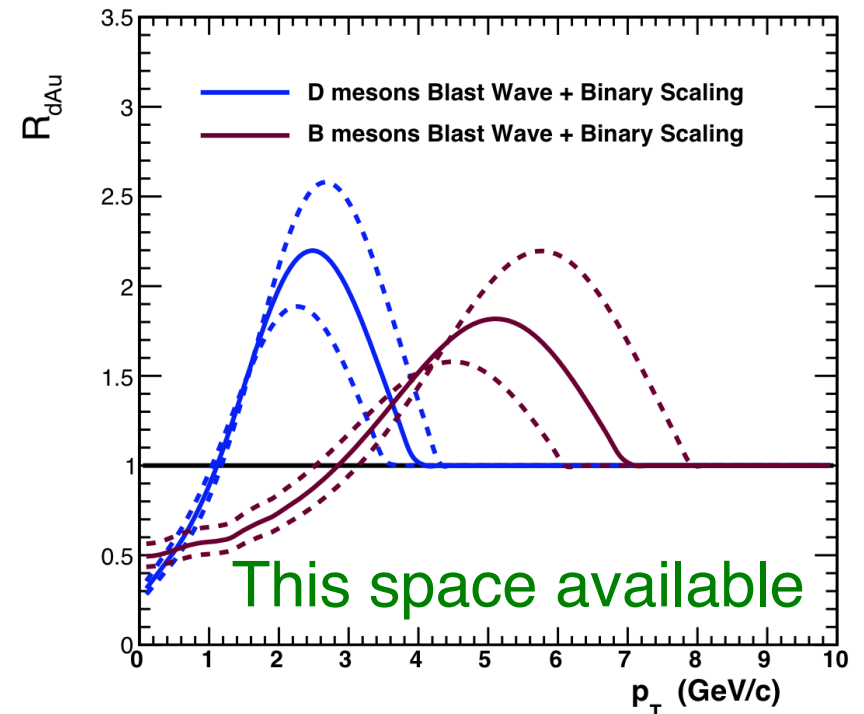
Phys. Rev. C 88, 024906 (2013)

Radial flow in d+Au?



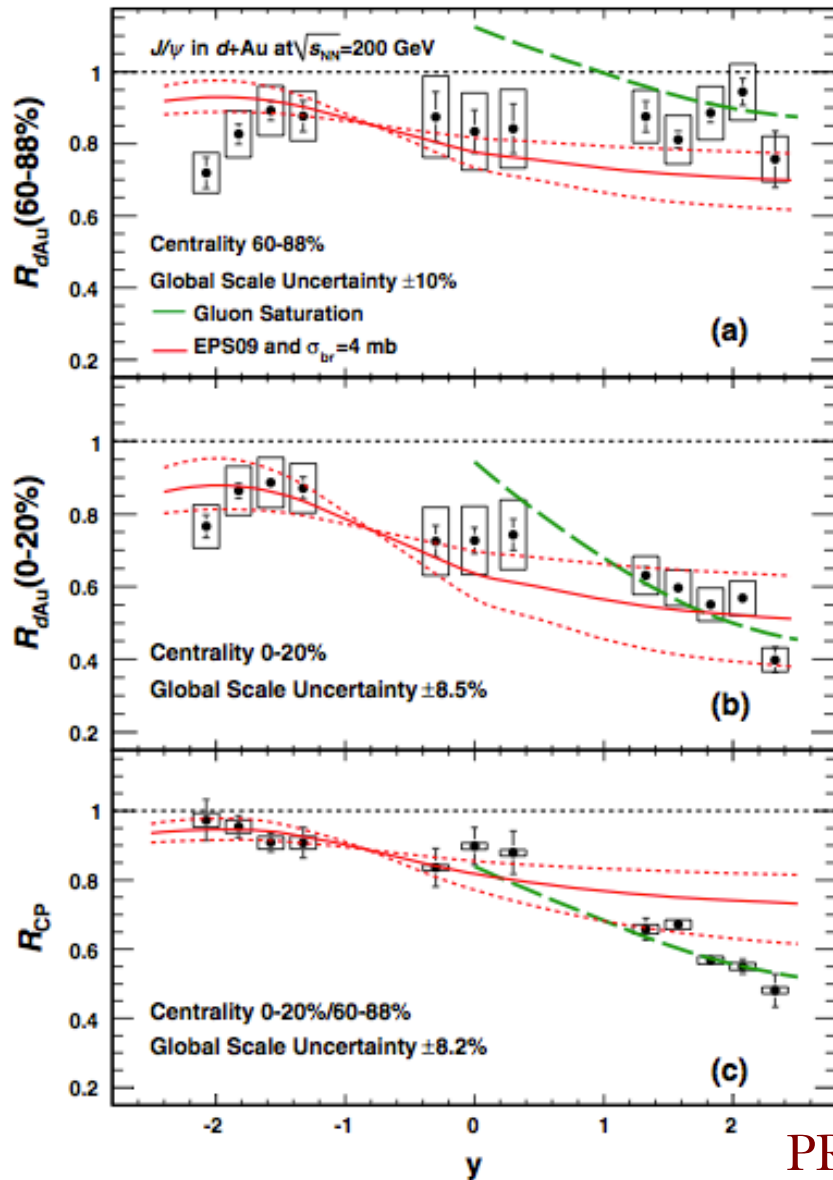
**Blast-wave fits to identified
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A. Sickles, Phys. Lett. B731 51-56 (2014),
“Possible Evidence for Radial Flow of
Heavy Mesons in d+Au Collisions”



**Heavy-flavor meson
predicted R_{dAu}**

Geometry of CNM effects?



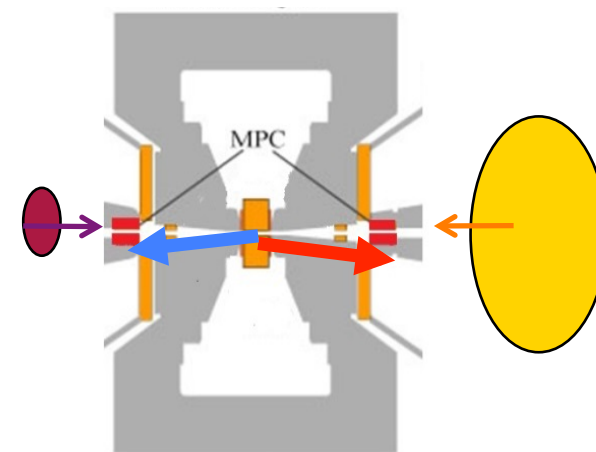
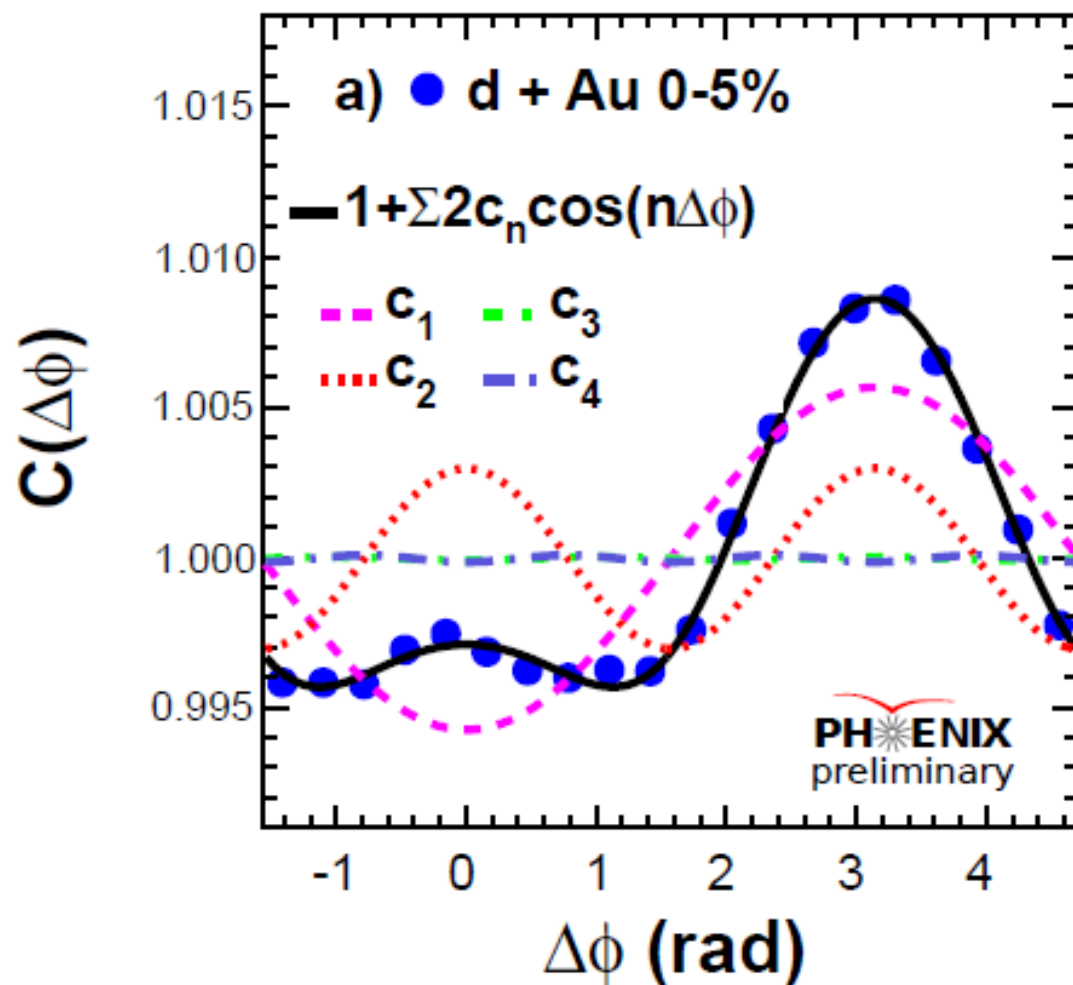
Peripheral

Central

R_{CP}

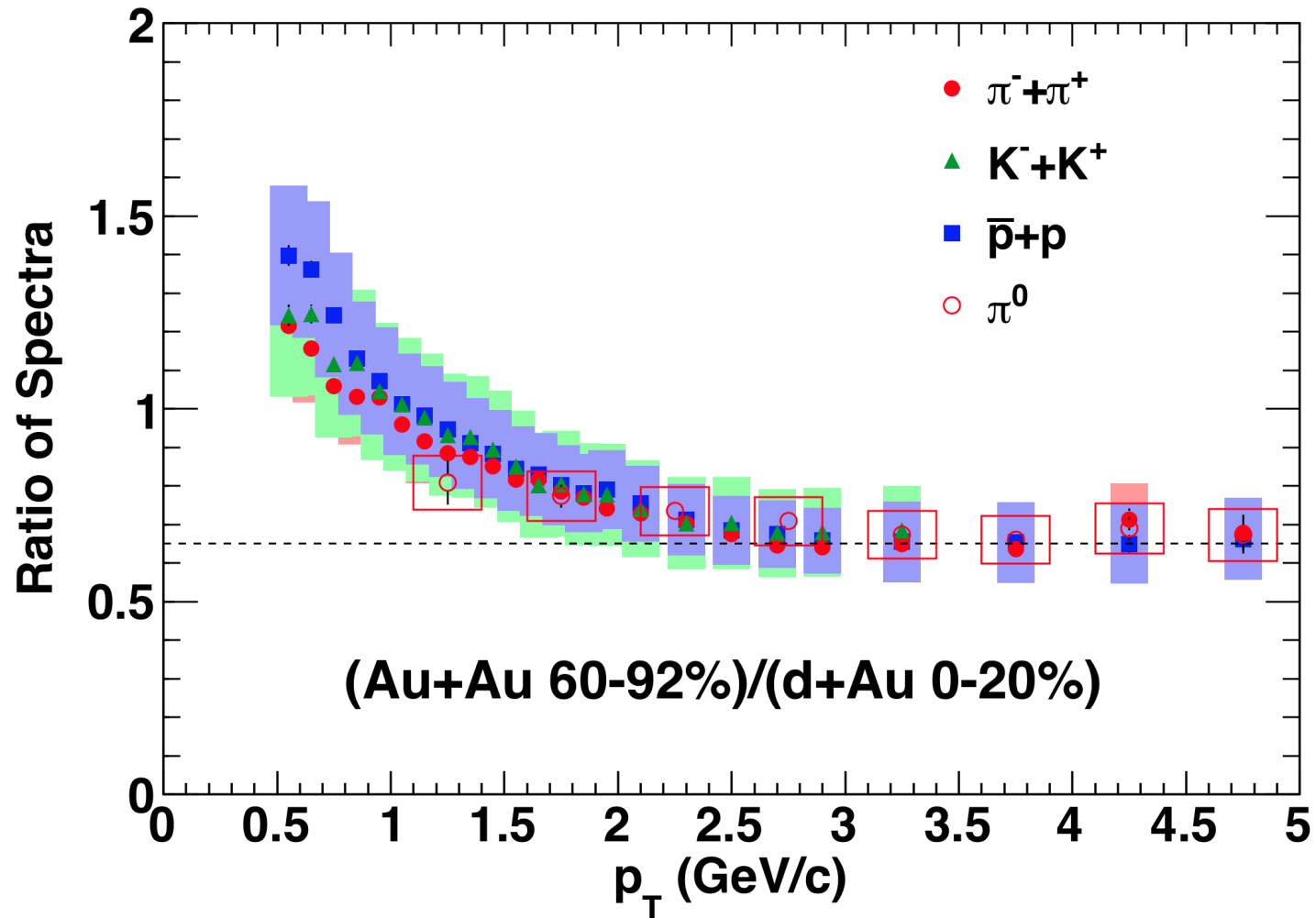
CNM modification
does *not* reproduce
centrality/geometry
dependence.

Near-side “ridge” over $\Delta\eta \sim 7$

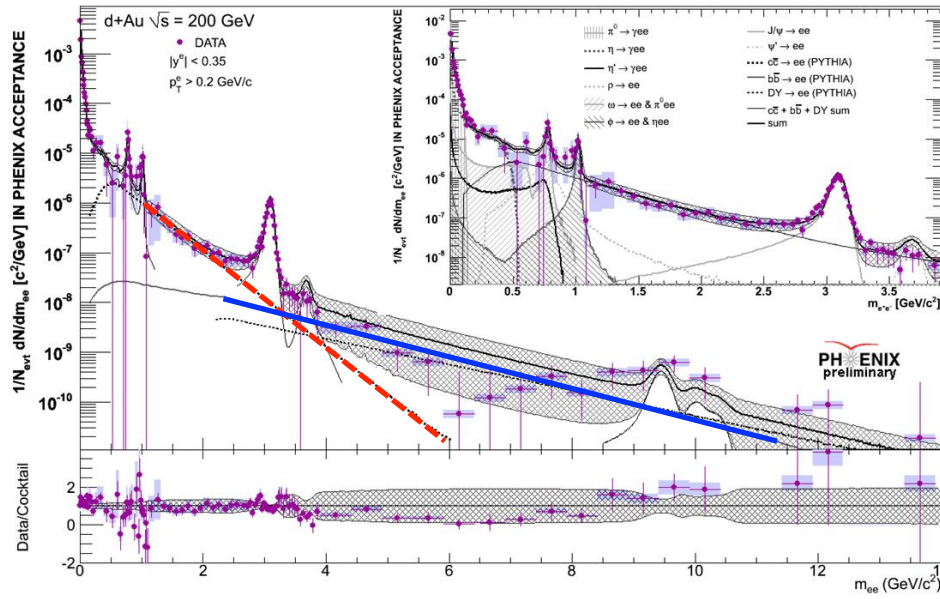


Correlation between
Au-going and
d-going MPC
towers

Periph Au+Au/Central d+Au



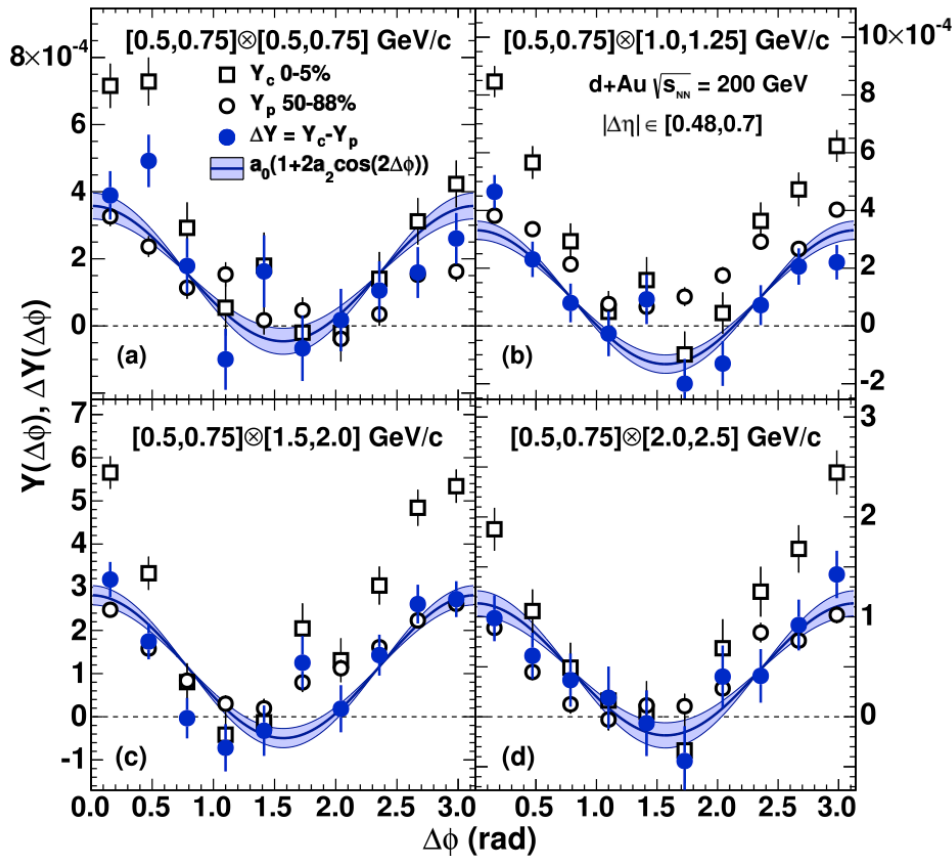
More news...



cc vs **bb** separation via
 dielectrons in d+Au
 across mass and p_T

Elliptic flow in d+Au?

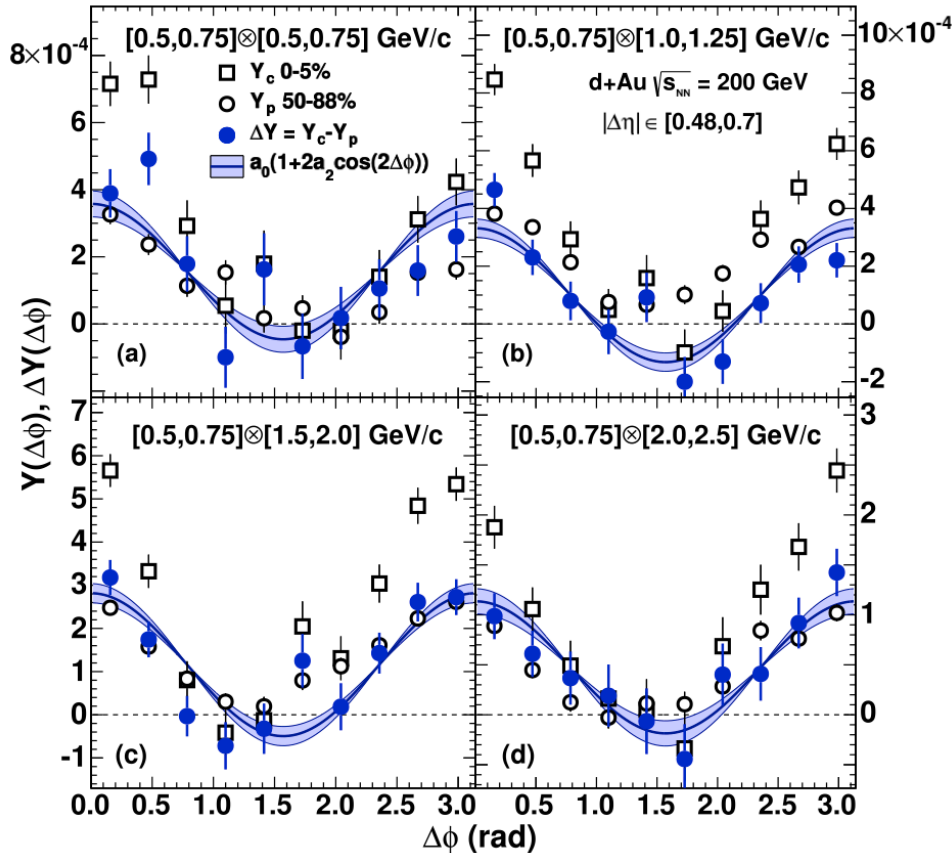
Charged pairs at mid-rapidity over $\Delta\phi$;
central, peripheral and difference



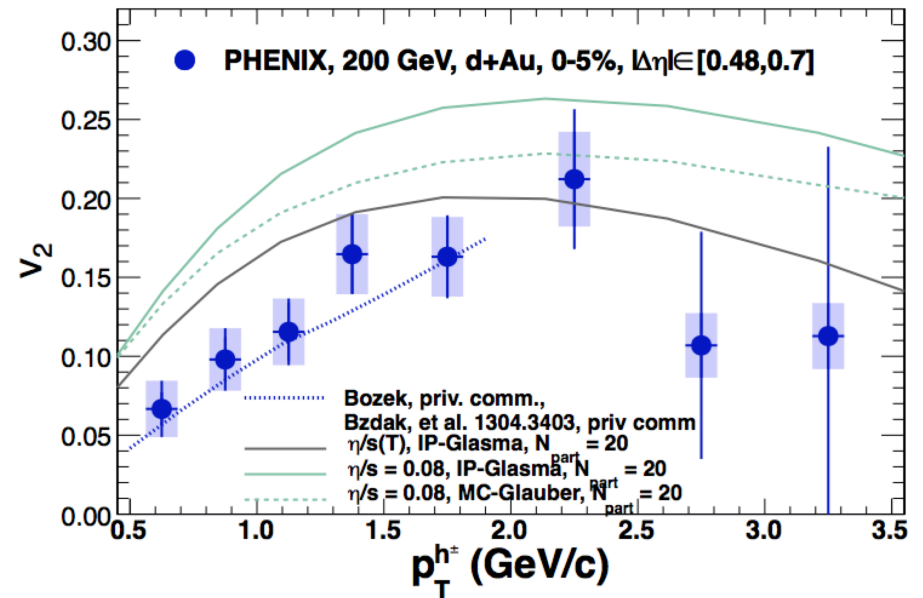
PRL 11, 212301 (2013)

Elliptic flow in d+Au?

Charged pairs at mid-rapidity over $\Delta\phi$;
central, peripheral and difference



PRL 11, 212301 (2013)

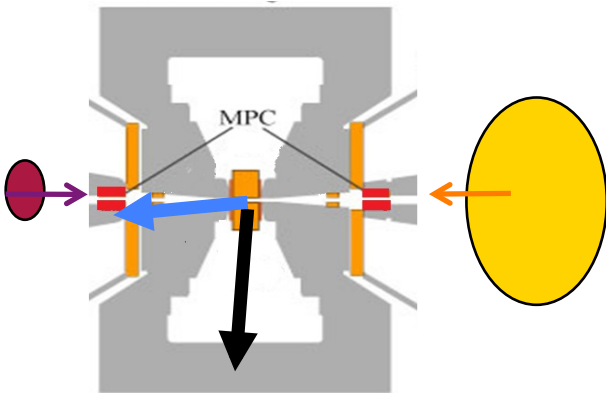


Quadrupole anisotropy allows
extraction of singles v_2

Caution: C-P subtraction may not
play well with jet modifications

Near-side “ridge” in d+Au?

Pair central arm tracks with MPC-S, $\Delta\eta \sim 3.4$



Near-side “ridge” in d+Au?

Pair central arm tracks with MPC-S, $\Delta\eta \sim 3.4$

p+p min-bias

